

# **Forward Premium Puzzle**

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## Abstract

Financial liberalizations in recent decades have prepared the way for the rapidly increasing number of studies related to the investigations of foreign exchange market efficiency in developing economies via testing for the uncovered interest parity (UIP) condition. Chapter 1 provides a survey on this recent literature. Specifically, it attempts to answer the following question: are the economies of developing countries different from those of developed countries in the context of the UIP condition?

Examining cross-country data, Bansal and Dahlquist (2000) found that the puzzling correlation between the exchange rate changes and the interest rate differentials of two countries appears less puzzling among developing countries than among developed countries. Several economists come up with new types of theoretical models that can explain the above new findings [e.g. Alvarez and Atkeson (2005), Bacchetta and Wincoop (2005, 2009)]. According to these models, when inflation is low, the exchange rate adjustment tends to be slow because adjustment is costly. This is why we observe the UIP puzzle in many developed countries where inflation rates are low. In Chapter 2, we cast doubt on these claims of the models by empirically examining the cross-country data. In essence, we argue that these models appear to solve the “nominal puzzle” but cannot solve the “real puzzle” of the UIP relation. After taking account of the relative PPP effect, we observe the same degree of the real UIP puzzle in both groups of countries.

The increasing international equity flows relative to bank loans or bonds constitutes a motivation to investigate a relationship of equity returns and exchange rate change. Under no-arbitrage condition, the expected returns on home equity market should equal those on the foreign equity market. This relation is known as the Uncovered Equity Party (UEP). In

Chapter 3, we propose an alternative method, called the UEP Ratio and UIP Ratio, to test the UEP relation and UIP relation, respectively. Examining time-series data for ten countries with developed financial markets, we find that UIP is less puzzling than we thought. Furthermore, unlike the literature, we find that UIP holds better than UEP. In addition, the UEP regression is a biased predictor of the deviation in UEP.

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## Chapter 1

### What Have We Learned about the Uncovered Interest?

#### 1.1 Introduction

The uncovered interest parity (UIP) condition is a no-arbitrage condition between investing in an asset denominated in domestic currency and an asset denominated in foreign currency such that the expected return from a foreign asset is equal to the return from a domestic asset as follows:

$$(1 + i_t) = (1 + i_t^*) \frac{E_t(S_{t+1})}{S_t}. \quad (1.1)$$

$S_t$  is the home currency price of the foreign currency.  $i_t$  and  $i_t^*$  denote asset interest rates denominated in domestic and foreign currency, respectively.

Log approximation of equation (1.1) yields

$$E_t(\Delta s_{t+1}) = i_t - i_t^*, \quad (1.2)$$

where  $\Delta = 1 - L$ ,  $s_t = \log S_t$ .

In other words, according to UIP, a speculator is indifferent between interest bearing identical assets denominated in different currency. UIP predicts that a high interest rate currency tends to depreciate against a low interest rate currency. The conventional way to test for the existence of UIP is to regress the exchange rate change on interest rate differential relative to a reference currency as follows:

$$\Delta s_{t+1} = \beta_0 + \beta_1(i_t - i_t^*) + \mu_{t+1}, \quad (1.3)$$

where  $\mu_{t+1}$  is an error term, and testing the joint hypothesis of  $\beta_0 = 0$  and  $\beta_1 = 1$ .

Assuming the covered interest parity (CIP) condition<sup>1</sup>, the UIP condition can also be estimated by regressing the exchange rate change on the forward premium as follows:

$$\Delta s_{t+1} = \beta_0 + \beta_1(f_t - s_t) + \mu_{t+1}, \quad (1.4)$$

where  $f_t$  is the forward rate.

Alternatively, UIP can be described in terms of excess returns from a carry trade. Consider the carry trade strategy in which investors borrow from a low interest rate currency and lend it in high interest rate currency; the excess return of this strategy can be defined by

$$z_{t+1} = (i_t - i_t^*) - \Delta s_{t+1}. \quad (1.5)$$

If UIP holds, payoff from a positive interest rate differential will be offset by the depreciation of the high interest rate currency such that excess returns should be zero. That is,

$$E_t(z_{t+1}) = 0. \quad (1.6)$$

## 1.2 UIP and Developing Countries

The wide-ranging survey performed by Engel (1996) not only rejects UIP hypothesis but also states that its prediction is of the opposite direction. That is, a high interest rate currency

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<sup>1</sup> The log approximation of CIP condition:  $f_t = i_t - i_t^*$ . Burnside et al. (2006) use the interbank interest rates for ten countries to test the implication of CIP, finding that the relation does hold.

tends to appreciate against a low interest rate currency. This is known as the UIP puzzle or forward premium puzzle.

Economists have not yet come to agreement on what the clear explanations are for the UIP puzzle. As an example, researchers such as Lustig and Verdelhan (2007) assert that aggregate consumption growth in the United States is central to understanding the UIP condition. Specifically, their work shows that high interest rate currencies usually decrease in value when US consumption growth is low, and US investors expect to be compensated for this risk. Conversely, Burnside (2007) disagrees with Lustig's and Verdelhan's study and uses the data from the same study, with a different specification of econometric model, to show that a model based solely on US consumption growth is not sufficient to explain the currency risk premium.

In addition, Burnside et al. (2008) studied an unbalanced panel of 20 major currencies with monthly data spans from 1976 to 2007 using U.S. dollar as a funding currency. For most of these currencies, the estimated slope coefficient is significantly negative, suggesting excess return from borrowing in low interest rate currencies and lending in high interest rate ones. Their study shows that excess return is significantly different from zero, but not statistically correlated with all single and groups of risk factors. Finally, they assert that sufficient evidence has not been found to support the idea that a "peso problem", or other rare disaster, can be used to explain the UIP puzzle.

Attempting to explain the UIP puzzle, Brunnermeir, Nagel, and Pedersen (2008) released a study consisting of a panel of nine major currencies from 1986 to 2006 that indicates that currencies with high interest rates have high negatively skewed excess returns which can be

interpreted as “crash risk.” This risk could limit arbitrage in currency speculation causing deviations from UIP.

Most studies focus on the existence of UIP in major currencies in developed countries. However, there are a number of recent empirical studies that analyze UIP in both developed economies and emerging markets. Bansal and Dahlquist (2000) show a difference between developed and emerging economies by using a panel of weekly data spanning from 1976 to 1998 to test an implication of UIP for twenty-eight advanced and emerging economies. Their results indicate that the UIP puzzle only exists in developed economies when the U.S. interest rate is higher than the interest rate of other developed countries. However, the puzzle does not seem to exist, and the estimate of the slope coefficient of equation (1.6) increases toward unity in emerging economies.

Conversely, Flood and Rose (2002) perform a study composed of thirteen developed economies and ten emerging markets using an unbalanced panel of daily data starting in the early 1990s and thus omitted the pre-1990 period in Bansal and Dahlquist (2000). This is notable since emerging markets around the world had only started reforming their financial accounts towards the end of the 1980s and the start of the 1990s. Because the study focused solely on post-1990 data, it excluded the effects of the aggregate shocks seen in the late 1970s and 1980s on the developed economies from the analysis of the UIP condition. Flood and Rose (2002) show that the deviation from UIP is less in their data sets than it is in older-period data. The slope coefficient estimates of UIP regression are positive, but the results indicate no significant differences between developed and emerging economies.

Frankel and Poonawala (2006) used data from December 1996 to April 2004 to analyze the forward premium puzzle in twenty-one developed countries and fourteen emerging

markets. Their results from an individual country and pooled analysis indicate that the UIP puzzle is present in developed countries. However, in emerging economies, the slope coefficient estimates are slightly positive on average. Frankel and Poonawala (2006) suggest that the exchange rate risk premium may not explain the UIP puzzle as emerging markets are perceived to have high risk, but deviate less from UIP.

Burnside, Eichenbaum, and Rebelo (2007) studied a panel of sixty three countries ( both developed and emerging economies) spanning the period of 1997 – 2006. According to their specified currency trading rules in which speculators never invest in twelve currencies and take less than ten trades in an additional twelve currencies in their dataset. They show that the Shape ratio increases when emerging market currencies are included, and excess returns from their trading strategy are not correlated with the U.S. stock market returns, suggesting that the risk premium cannot explain excess returns.

In short, most studies find that the puzzling correlation between the exchange rate changes and the interest rate differentials of two countries appears less puzzling among developing countries than among the developed countries. Why developing and developed countries are so different in terms of UIP is investigated in Chapter 2.

## Chapter 2

### Real and Nominal Puzzles of the Uncovered Interest Parity

#### 2.1 Introduction

It has long been known that the uncovered interest parity (UIP) relation rarely holds empirically.<sup>2</sup> The UIP slope coefficient is often not only less than unity but also negative. In other words, the future exchange rate change is not just far from what is predicted from the current nominal interest rate differential between two countries. But predicting in the opposite direction from the UIP is often better than otherwise. This disastrous empirical failure of the most fundamental theoretical relation in international finance prompts many papers which claim to have found either new theoretical models able to explain the apparent inconsistencies, or new empirical procedures able to find what is consistent with the conventional theory<sup>3</sup>.

One of the most interesting empirical findings in the literature which attracts a great deal of attention recently is Bansal and Dahlquist (2000). Examining cross-country data, they found that the puzzling correlation between the exchange rate change and the interest rate differentials of two countries appears less puzzling among developing countries than among

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<sup>2</sup> Engle (1996) provides a comprehensive survey of the literature.

<sup>3</sup> Fama (1984) shows that, to cause the exchange rate anomaly, the risk premium must be more volatile than and negatively correlated with the exchange rate change. Since then, there are many attempts to explain the “forward premium puzzle” by a risk premium. Among others, Engel and Frankel (1984), Engle and Rodrigues (1989) and Mark (1988) use the international CAMP approach that generates a risk premium. Lustig and Verdelhan (2007) assert that aggregate consumption growth in the U.S. is central to understanding the UIP condition. Other explanations include the “peso problem”. Evans and Lewis (1995) show that the “peso problem” may have an effect on an inference of the risk premium. Unfortunately, none of those attempts can yet solve the puzzle successfully. Burnside et al. (2008) show that the risk premium is not correlated with any risk factor, and there is not enough evidence to support the “peso problem”, or other rare disaster, being used to explain the UIP puzzle.

the developed countries.<sup>4</sup> They argue that the presence of the forward premium is attributed to each country specifics, especially, average inflation and expected inflation which are considered as evidence of segmented markets.

Several economists come up with a new theoretical models that can explain the above new findings [e.g. Alvarez and Atkeson (2005), Bacchetta and Wincoop (2005, 2009)]. According to these models, when inflation is low, the exchange rate adjustment tends to be slow because adjustment is costly. This is why we observe the UIP puzzle in many developed countries where inflation rates are low.<sup>5</sup>

The purpose of this paper is not to solve the puzzle; however, we cast doubt in these claims of the models by empirically examining the cross-country data. In essence, we argue that these models appear to solve the “nominal puzzle” but cannot solve the “real puzzle” of the UIP relation. After taking account of the relative PPP effect, we observe the same degree of the real UIP puzzle in both groups of countries. It appears that the exchange rate change in the high-inflation group is a result of the relative PPP relation rather than the UIP relation.

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<sup>4</sup> In particular, they found the coefficient of the UIP regression is slightly positive in developing countries. It is not that the UIP holds in developing countries, but that the puzzle is not as extreme as in the developed countries. More specifically, they found coefficients of the UIP regression are -0.32 and 0.19 in developed and developing countries, respectively. In addition, Frankel and Poonawala (2006) found coefficients of the UIP regression are -1.67 and 0.15 for emerging market and advanced economies, respectively.

<sup>5</sup> To explain a deviation from UIP, Alvarez and Atkeson (2005) attributed the failure of UIP to time-varying risk premia occurred in segmented asset markets in which investors have limited participation due to fixed costs. When inflation is low, the markets are segmented. But when inflation is high, most investors choose to pay the fixed costs, so that the markets are less segmented leading to constant risk premia, thus less deviation from UIP. Bacchetta and Wincoop (2005) argued that a deviation from UIP can be explained by expectation errors about future exchange rates. They claim that the inattentiveness of investors in portfolio decisions is the cause of these errors. Bacchetta and Wincoop (2009) attributed the deviation from UIP to infrequent revisions of portfolios due to fixed costs. Their model predicts that persistent high inflation will raise the depreciation rate and interest rate differentials by the same amount causing high coefficient in UIP regression.

Comparing the cross section plots of excess returns against inflation differentials of the low and high-inflation periods, Gilmore and Hayashi (2008) find that the estimated UIP slope coefficient is large for developing countries because of their high inflation. In this paper, we introduce the decomposed and augmented UIP regressions to numerically decompose the UIP and relative PPP effects on the exchange rate change. We also compare the “real UIP” relation between low and high-inflation countries.

The organization of the rest of the paper is as follows. In the next section, we develop the distinction between nominal and real UIP puzzles, and formulate a way to examine each component. In section 2.3, we report our empirical findings. A brief conclusion is given in section 2.4.

## 2.2 Nominal and Real Puzzles

To entangle the puzzles underlying the UIP relation, we consider the following empirical framework. We introduce five simple regressions, discuss their relationship, and then distinguish the real puzzle from the nominal puzzle of the UIP.

First, we express the UIP relation in a log approximation form as

$$E_t(\Delta s_{t+1}) = i_t - i_t^*, \quad (2.1)$$

where  $\Delta = 1 - L$ ,  $L$  is a lag operator,  $s_t = \log S_t$ , and  $S_t$  is the home currency price of the foreign currency. Conventionally, the UIP relation is tested by running the UIP regression,

$$\Delta s_{t+1} = \beta_0 + \beta(i_t - i_t^*) + u_{t+1}, \quad (2.2)$$

and examine the size of the coefficient  $\beta$ . In this context, we say that the UIP puzzle exists if the null hypothesis that  $\beta = 1$  is rejected by data. We also say the “extreme version of the UIP puzzle” exists if  $\beta$  is significantly negative.

It is important to emphasize that empirically, the exchange rate change can be predicted by not only the interest rate differential via the UIP relation but also the inflation differential via the relative PPP relation. Relative PPP is the equilibrium in the goods market. Therefore, it is crucial to distinguish whether the exchange rate change is due to the asset market (UIP relation) or goods market (relative PPP relation).

There exists a reason to believe that the real interest rate is different across countries. For example, different countries have different production functions and, so, the marginal product of capital. Under the assumption that the real interest rate is not the same for all countries, the real interest rate differential affects the expected exchange rate change via the UIP channel. Also, the expected exchange rate change can be predicted by the expected inflation differential via the relative PPP channel.

Consider the relative purchasing power parity (PPP) relation, we consider the relative PPP in the form as

$$\Delta s_{t+1}^+ = \pi_{t+1} - \pi_{t+1}^*, \quad (2.3)$$

where  $\Delta s_{t+1}^+ = s_{t+1}^+ - s_t$ ,  $s_{t+1}^+$  is the long-run equilibrium value of the exchange rate at  $t + 1$ ,  $\pi_t$  is the home inflation rate, and  $\pi_t^*$  is the foreign inflation rate. The actual exchange rate at  $t + 1$  can then be thought of as the partial adjustment outcome between the current rate  $s_t$  and the equilibrium rate  $s_{t+1}^+$

$$s_{t+1} = \alpha s_{t+1}^+ + (1 - \alpha)s_t, \quad (2.4)$$

where  $\alpha$  measures the adjustment speed ( $0 < \alpha < 1$ ). Taking the conditional expectation of (4) given the information up to time  $t$  and using (3) yields

$$\begin{aligned} E_t(s_{t+1}) &= \alpha E_t(s_{t+1}^+) + (1 - \alpha)s_t \\ &= \alpha[s_t + E_t(\pi_{t+1} - \pi_{t+1}^*)] + (1 - \alpha)s_t \end{aligned}$$

which implies

$$E_t(\Delta s_{t+1}) = \alpha(\pi_{t+1}^e - \pi_{t+1}^{*e}),$$

where  $\pi_{t+1}^e = E_t(\pi_{t+1})$  and  $\pi_{t+1}^{*e} = E_t(\pi_{t+1}^*)$ . This relation can be written as

$$\Delta s_{t+1} = \alpha(\pi_{t+1}^e - \pi_{t+1}^{*e}) + \varepsilon_t, \quad (2.5)$$

where  $\varepsilon_t = \Delta s_{t+1} - E_t(\Delta s_{t+1})$ . We call (2.5) the “relative PPP regression.”

We use the Fisher equation to write the nominal interest differential as

$$i_t - i_t^* = (r_t - r_t^*) + (\pi_{t+1}^e - \pi_{t+1}^{*e}),$$

where  $r_t = i_t - \pi_{t+1}^e$  and  $r_t^* = i_t^* - \pi_{t+1}^{*e}$  are the real interest rates in the home and foreign countries, respectively. Substituting this relationship into (2.1), we rewrite the UIP relation as

$$E_t(\Delta s_{t+1}) = (r_t - r_t^*) + (\pi_{t+1}^e - \pi_{t+1}^{*e}), \quad (2.6)$$

and the UIP regression as

$$\Delta s_{t+1} = \tilde{\beta}_0 + \beta_1^*(r_t - r_t^*) + \beta_2^*(\pi_{t+1}^e - \pi_{t+1}^{*e}) + \tilde{u}_{t+1}. \quad (2.7)$$

In regression (2.7), exchange rate change correlates with real interest rate differential and expected inflation differential.<sup>6</sup> Note: if  $\beta_1^* = \beta_2^*$ , regression (2.7) reduces to the original equation in the sense that the regression (2.2) is simply a restricted version of regression (2.7) with constraint  $\beta_1^* = \beta_2^*$ . An advantage of using regression (2.7) is that we could find whether deviation from the UIP relation comes from the real part or expected inflation part. The source of deviation of the original UIP regression is depending on either  $\beta_1^*$  or  $\beta_2^*$  deviation from unity. So, we reparameterize the regression (2.7) as

$$\Delta s_{t+1} = \tilde{\beta}_0 + \beta_1(i_t - i_t^*) + \beta_2(\pi_{t+1}^e - \pi_{t+1}^{*e}) + \tilde{u}_{t+1}. \quad (2.8)$$

In regression (2.8), exchange rate change correlates with the nominal interest rate differential and expected inflation differential. Since the original UIP regression is augmented by the expected inflation differential, we call regression (2.8) the augmented UIP regression. Regression (2.8) is simply reparameterization of (2.7) in the sense that the space spanned by  $(r_t - r_t^*)$  and  $(\pi_{t+1}^e - \pi_{t+1}^{*e})$  is the same as the space spanned by  $(i_t - i_t^*)$  and  $(\pi_{t+1}^e - \pi_{t+1}^{*e})$ . In other words, regressions (2.7) and (2.8) are identical with reparameterization  $\beta_1 = \beta_1^*$  and  $\beta_2 = \beta_2^* - \beta_1^*$ .

In regression (2.8), if  $\beta_2 = 0$ , regression (2.5) reduces to the original UIP regression (2.2). On the other hand, if  $\beta_1 = 0$ , regression (2.8) becomes regression (2.5), or in other words, the augmented UIP regression reduces to the relative PPP regression.

To derive the real UIP relation, we applied the Fisher equation and considered the UIP regression in real terms. So we subtract  $(\pi_{t+1}^e - \pi_{t+1}^{*e})$  from both sides of the UIP equation (2.1) to obtain

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<sup>6</sup>  $\pi_t^e$  and  $\pi_t^{*e}$  are unobservable. We discuss in the next section how to estimate them.

$$E_t(\Delta q_{t+1}) = r_t - r_t^* \quad (2.9)$$

where  $q_t = \log Q_t = \log\left(\frac{S_t P_t^*}{P_t}\right)$  is the real exchange rate<sup>7</sup>. (2.9) defines the real UIP relation.

Based on this relation, we specify the real version of regression (2.2) as

$$\Delta q_{t+1} = b_0 + b(r_t - r_t^*) + v_{t+1} \quad (2.10)$$

We call (2.10) the real UIP regression. We say that the real UIP puzzle exists if the null hypothesis that  $b = 1$  is rejected by data, and that the “extreme version of the real UIP puzzle” exists if  $b$  is significantly negative.

Bansal and Dahlquist (2000) found that correlation  $\beta$  is not necessary negative in the original UIP regression for developing countries although it is mostly negative in developed countries. In other words, the extreme version of the UIP puzzle does not exist in developing countries. In the next section, we try to discover the main sources for making the deviations from the UIP so different between the developed country group and the emerging market country group by comparing the empirical results of the five regressions.

So far, we have developed 5 regressions: (2.2), (2.5), (2.7), (2.8), and (2.10). In the next section, we used these regressions to find out nature of the UIP puzzle more closely.

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<sup>7</sup> (2.9) can be obtained by noticing  $\Delta q_{t+1} = \log\left(\frac{S_{t+1} P_{t+1}^*}{P_{t+1}}\right) - \log\left(\frac{S_t P_t^*}{P_t}\right) = \log\left(\frac{S_{t+1}}{S_t}\right) - \log\left(\frac{P_{t+1}}{P_t}\right) + \log\left(\frac{P_{t+1}^*}{P_t^*}\right) = \Delta s_{t+1} - (\pi_{t+1} - \pi_{t+1}^*)$ .

## 2.3 Empirical Results

### 2.3.1 Data

The data we use in our empirical investigation are quarterly data on exchange rates, interest rates, inflation rates, unemployment rates, and real GDP in 42 countries over the first quarter of 1994 through the first quarter of 2009. The exchange rate in each country is the price of each currency in terms of US dollars. The interest rate is the 3-month interbank interest rate in the London market. The inflation rate is based on the CPI.<sup>8</sup>

Since real interest rates and real exchange rates are unobservable, it is necessary to obtain expected inflation rates. There are two ways: surveys and forecasting model. To estimate the expected inflation, we calculate a one-step-ahead (out of sample) inflation forecast at each quarter for each country based on the forecasting model suggest by Stock and Watson (1999). More specifically, we first fit the Phillips curve model

$$\pi_t = \alpha_0 + \sum_{i=1}^p \alpha_{1i} \pi_{t-i} + \sum_{i=1}^q \alpha_{2i} x_{t-i} + u_t, \quad (2.11)$$

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<sup>8</sup> The data on daily spot exchange rates are from the Datastream of the WM Company/Reuters, except the euro, which is from Barclay's Bank International. The interbank Eurocurrency interest rates data are from the Datastream for the middle rates and from the British Bankers' Association for the offered rates; the U.S. interbank daily middle and offered rates are used as a reference to calculate interest rate differentials. Due to the lack of availability of data on the interbank Eurocurrency interest rates, the domestic interbank interest rates from the Datastream and the Global Financial Data are used for some countries. All CPI and GDP data are from the IMF. The data on unemployment rates are from the IMF and OECD. Data sources for each country are shown in Table A1. The daily data is converted into quarterly data using the first working day for each quarter with the U.S. as the home country. We exclude Argentina in 2002Q2 and 2002Q4, Russia in 1998Q4, Romania in 1999Q2 and Turkey in 2003Q2 from our sample because the irregularity in the data.

where  $x_{t-i}$  stands for the lagged unemployment rate. The lag length  $p$  and  $q$  are determined according to the Schwarz's Bayesian information criterion. Then we estimate  $\pi_{t+1}^e$  by calculating the one-quarter-ahead forecast based on the estimated coefficients in each step.<sup>9</sup>

The inflation expectation calculated above is not necessary a public expectation of inflation. However, public expectation is based on information provided by specialists who use econometric models. Therefore, public expectation is roughly approximated by the best perform forecasting model. Stock and Watson did experiment on many models, and found that (2.11) is the best econometric model to forecast inflation.

### **2.3.2 Empirical Results**

Examining cross-country data, Bansal and Dahlquist (2000) found that the negative slope of the UIP regression is not universally observed but mainly occurs in developed countries. Rather than classify these countries into developed and developing economies [as Bansal and Dahlquist (2000) did], we instead classify them into high inflation and low inflation countries. Surprisingly, our classification still yields similar groupings of countries as did Bansal and Dahlquist's developed/developing classification (2000). In fact, the groupings of the two classifications are virtually identical, with high inflation overlapping with developing countries and low inflation overlapping with developed countries. More specifically, in our classification, we call a country with an average annual inflation rate of less than 3.2% a low inflation country. We call a country with an average annual inflation rate of more than 3.2% a high inflation country. Due to our alternative classification, all developed countries in our

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<sup>9</sup> For simplicity, we set the lag length  $p = q$ . We use a change in real GDP in place of unemployment rate for Argentina, Denmark, Netherlands, South Africa and Thailand because the latter data are not available. We use only lagged inflation for Croatia, Egypt, Greece, Iceland, India, Indonesia, Pakistan, Romania, Russia and Singapore since neither unemployment nor GDP are available.

sample have an average inflation rate that is less than 3.2%. All developing and emerging economy countries in our sample have an average inflation rate higher than 3.2%. Exceptions are Hong Kong and Singapore, which we classify into developed countries.

To provide the ground for comparing the real and nominal UIP regressions, we investigate the variations of real and nominal exchange rate changes. Table 2.1 displays the unconditional variance of changes in nominal exchange rates, real exchange rates, and ex-post inflation differentials for low and high inflation countries. We find that the variation in nominal exchange rate changes largely comes from the variation in real exchange rate changes. Therefore, the variations to be explained in the real and nominal UIP regressions are not different.

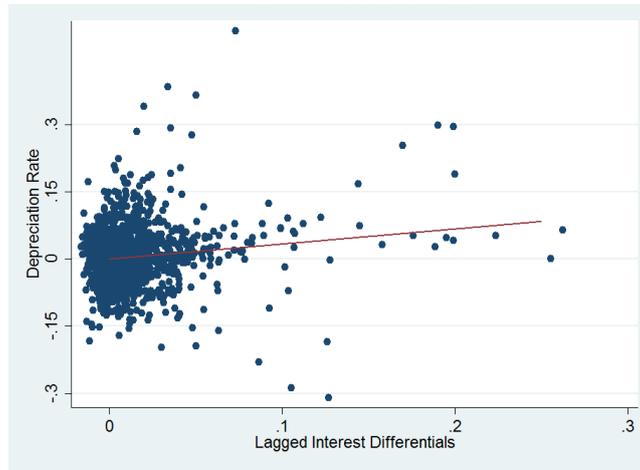
**Table 2.1: Volatilities Statistics**

	$V(\Delta s_{t+1})$	$V(\Delta q_{t+1})$	$V(\pi_{t+1} - \pi_{t+1}^*)$	$\frac{V(\Delta q_{t+1})}{V(\Delta s_{t+1})}$	$\frac{V(\pi_{t+1} - \pi_{t+1}^*)}{V(\Delta s_{t+1})}$
Low Inflation Countries	0.00237	0.00230	0.00005	0.97046	0.02109
High Inflation Countries	0.00482	0.00407	0.00089	0.84440	0.18463

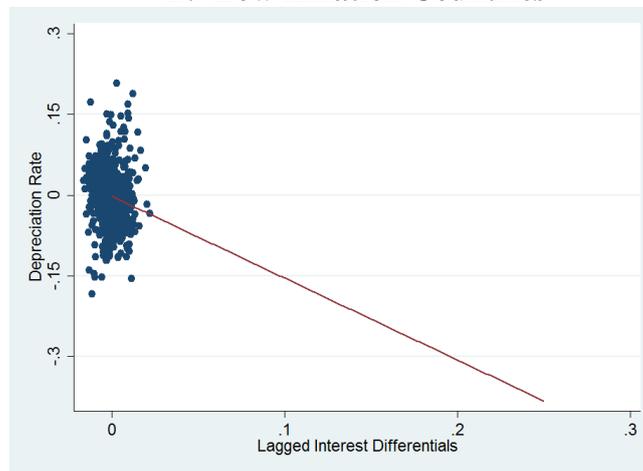
*Notes:*  $V(\cdot)$  stands for the unconditional variance.

Figure 2.1A presents the plots of the pairs of the exchange rate change and interest rate differential for all countries. The regression line appears to have a slightly positive slope. Figures 2.1B and 2.1C show the same plots for the groups of low and high inflation countries separately. They illustrate that the regression lines for two groups are strikingly different. The low inflation group exhibits negative slope, while the high inflation group shows positive slope.

### A. All Countries



### B. Low Inflation Countries



### C. High Inflation Countries

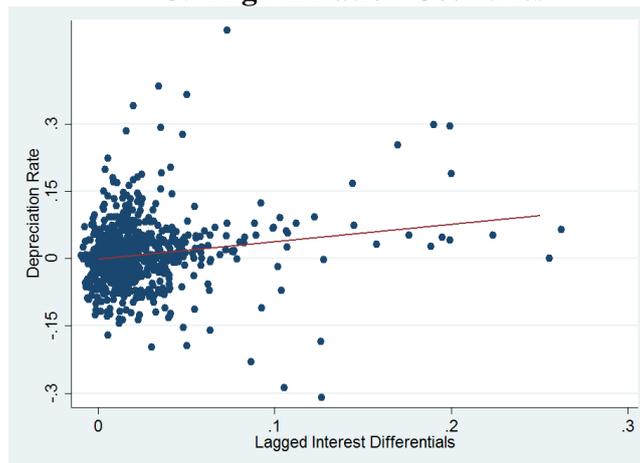


Figure 2.1: Exchange Rate Changes and Interest Rate Differentials

This contrast can be seen more clearly in Table 2.2. The first two columns of the table report the estimates of the slope coefficient in regression model (2.3) for low and high inflation countries groups. The estimated coefficient is significantly negative for the low inflation countries group. It is this observation where we usually find the extreme version of the UIP puzzle. The coefficient for the high inflation group, on the other hand, is estimated to be significantly positive but still far from satisfying the UIP relation (see Table 2.2B). It would be rather incorrect to say that the UIP puzzle is absent in high inflation countries. The point has been known since Bansal and Dahlquist (2000).

**Table 2.2: Nominal UIP Regressions**

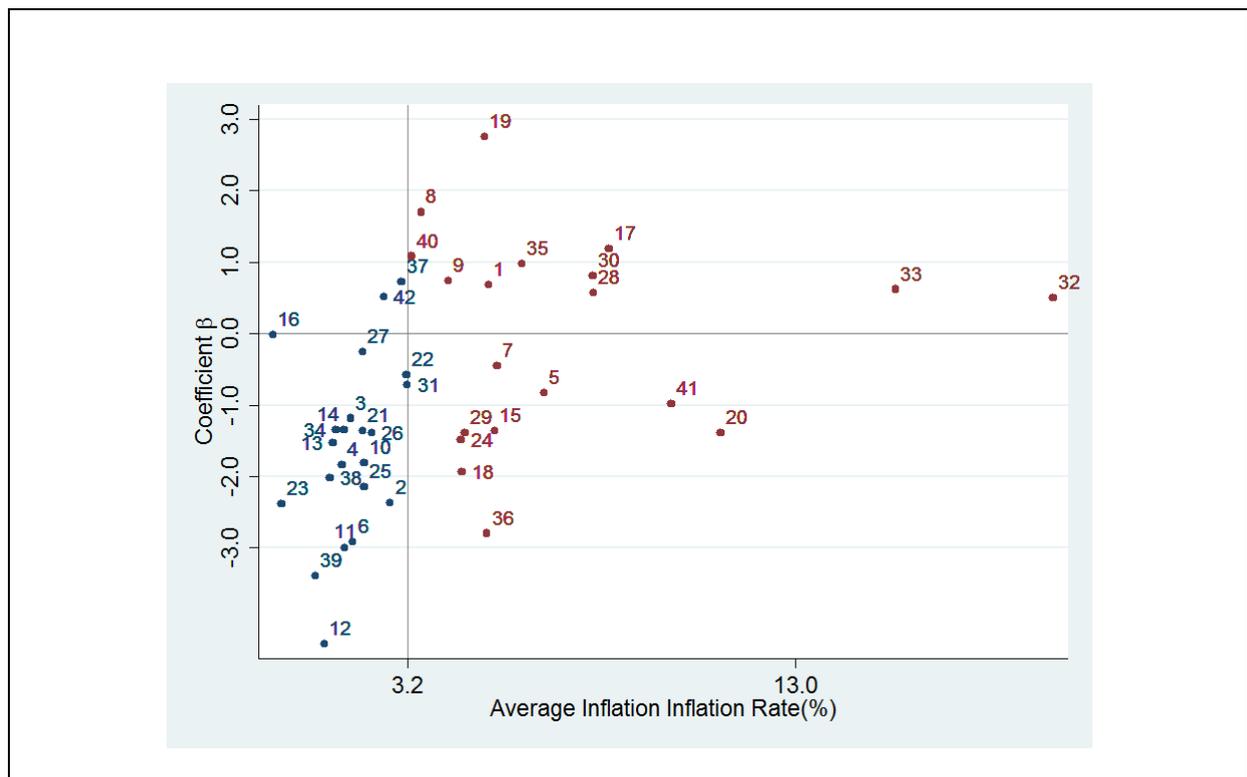
	Low Inflation	High Inflation	Low Inflation	High Inflation
	$\Delta s_{t+1}$	$\Delta s_{t+1}$	$\Delta s_{t+1}$	$\Delta s_{t+1}$
Independent Variable	(1)	(2)	(3)	(4)
<i>A. Fixed Effects Regression</i>				
$i_t - i_t^*$	-1.523** (0.275)	0.388* (0.147)	-1.519** (0.447)	-0.077 (0.185)
$\pi_{t+1}^e - \pi_{t+1}^{*e}$			-0.024 (0.363)	0.721** (0.207)
$R^2$	0.018	0.021	0.018	0.058
$N$	855	846	855	855

**B. Hypothesis Testing**

Null Hypothesis	$t$ -statistic	$p$ -value
$\beta_L = 1$	9.17**	0.000
$\beta_H = 1$	4.18**	0.001
$\beta_L = \beta_H$	6.13**	0.000
$\beta_{1L} = \beta_{1H}$	2.98**	0.001

*Notes:* 1. Nominal UIP is given in regression (2.2):  $\Delta s_{t+1} = \beta_{0i} + \beta_i(i_t - i_t^*) + u_{t+1}$ ; the augmented UIP is given in regression (2.8):  $\Delta s_{t+1} = \tilde{\beta}_i + \beta_{1i}(i_t - i_t^*) + \beta_{2i}(\pi_{t+1}^e - \pi_{t+1}^{*e}) + \tilde{u}_{t+1}$ , where  $i = L$  for low inflation countries and  $i = H$  for high inflation countries.  
2. The hypothesis testing is performed using the two-tailed test.  
3. Numbers in parentheses are robust standard errors for regression (2.2) and are bootstrapped standard errors to account for the generated regressor in regression (2.8). \* indicates significance at 5-percent level. \*\* indicates significance at 1-percent level.

Figure 2.2 further illuminates the relation between the UIP regression coefficient for each country (vertical axis) and the average inflation rate (horizontal axis). The vertical line of the average inflation rate = 3.2 is the inflation cutoff line where the plots on the left of the line is considered for low inflation countries and the plots on the right of the line is considered for high inflation countries. It is constructed by first running the UIP regression country by country to obtain the estimate of the slope coefficient. Then, we plot the estimated coefficient against the average inflation for each country. It reveals a striking contrast. Among low inflation group, the negative slope dominates. Twenty countries out of twenty two members in this group have the slope coefficients estimated negatively. In contrast, the signs of the slope estimates are divided almost evenly among the countries in high inflation group; positive in eleven countries and negative in nine countries.



**Figure 2.2: The Nominal UIP Regression Coefficients and Average Inflation Rate**

The above observation motivates us to investigate further the UIP relation and the expected inflation differential. We run two additional regressions. First, the expected inflation differential is included to the UIP relation, and the augmented UIP regression (2.8) is run. Second, we drop the interest differential from the regression (2.8) and run the relative PPP regression (2.5).

The third and fourth columns of Table 2.2 report the result of the augmented UIP regression<sup>10</sup>. We find a striking difference again between the two groups of countries. In the low inflation group, the interest differential has a significant negative impact, but the expected inflation differential is insignificant. The opposite is true for the high inflation group; the impact of the expected inflation differential overwhelms that of the interest differential, and the latter is insignificant. We have an impression now that the source of the highly significant positive estimate (for the high inflation group in the original UIP regression) appears to be expected inflation differential rather than interest differential itself. In contrast, there is little change in the estimated coefficient on the nominal rate of differential between the original UIP regression and the augmented regression equation (2.8) (Columns 1 and 3).

Table 2.3 reports the result of the relative PPP regression (2.5). Dropping the interest differential as a regressor turns out to have a critical impact on the coefficient on the inflation differential in the low inflation group but almost no impact in the high inflation group. In other words, if the expected inflation differential is included in the UIP relation, the augmented UIP

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<sup>10</sup> Engle (2011) calculates the ex-ante real interest rate differential using the predicted inflation from VAR. He corrects the standard error to account for the generated regressor in the real UIP regression using the bootstrap method for 1,000 repetitions. We follow his technique to account for generated regressors in our models.

regression effectively reduces to the relative PPP regression. Results in table 2.3 suggest that the exchange rate change in the high-inflation group is a result of the relative PPP relation.

**Table 2.3: Relative PPP Regressions**

	Low Inflation	High Inflation
	$\Delta s_{t+1}$	$\Delta s_{t+1}$
Independent Variable	(1)	(2)
$\pi_{t+1}^e - \pi_{t+1}^{*e}$	-0.192 (0.368)	0.668** (0.164)
$R^2$	0.000	0.058
$N$	855	846

*Notes:* 1. Relative PPP is given in regression (2.5).  
 2. Numbers in parentheses are Bootstrapped standard errors. \* indicates significance at 5-percent level.  
 \*\* indicates significance at 1-percent level.

Since we discover that the variations to be explained in the real and nominal UIP regressions are not different as shown in Table 2.1, we can step further to the real UIP regression where the real-exchange rate change is regressed on the real interest rate differential. The real UIP regression accounts for inflation differential between a country pair. Table 2.4 reports the results. The slope coefficients for both low and high inflation countries are different from unity. This is the “real puzzle” of the UIP relationship. We also find the slope coefficient for low and high inflation countries are not significantly different from each other (Table 2.4B). Unlike in the nominal UIP regression, the two groups of countries behave similarly in the context of real UIP.

**Table 2.4: Real UIP Regressions**

	Low Inflation	High Inflation
	$\Delta q_{t+1}$	$\Delta q_{t+1}$
Independent Variable	(1)	(2)
<i>A. Fixed Effects Regression</i>		
$r_t - r_t^*$	0.172	0.082
	(0.287)	(0.169)
$R^2$	0.001	0.001
$N$	855	846

**B. Hypothesis Testing**

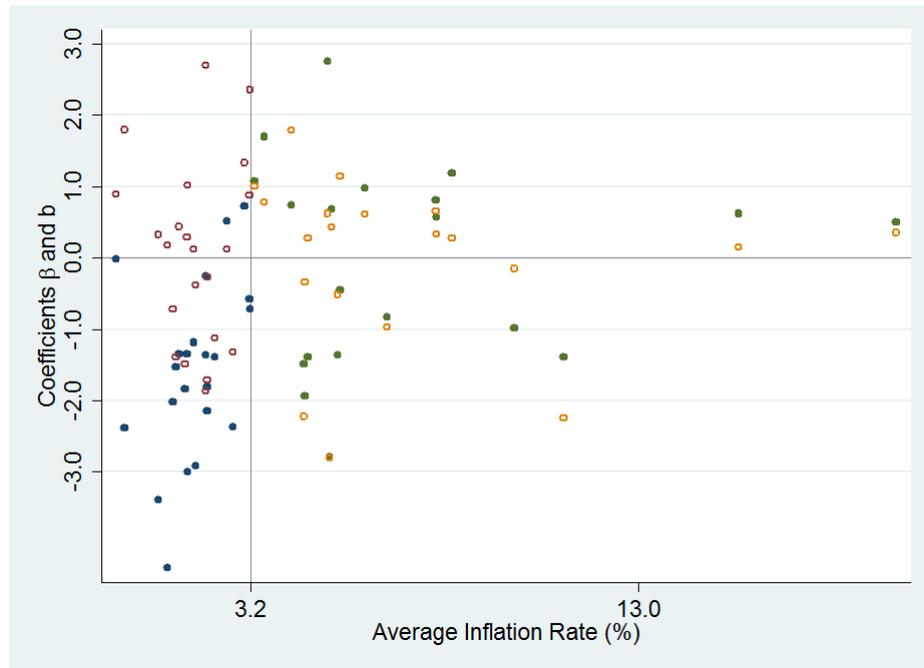
Null Hypothesis	$t$ -statistic	$p$ -value
$b_L = 1$	2.89**	0.004
$b_H = 1$	5.43**	0.000

*Notes:* 1. Real UIP regression is given in regression (2.10):  $\Delta q_{t+1} = \mathbf{b}_0 i + \mathbf{b}_i (r_t - r_t^*) + \mathbf{v}_{t+1}$ ,  $i = L$  for low inflation countries and  $i = H$  for high inflation countries.  
2. The hypothesis testing is performed using the two-tailed test.  
3. Numbers in parentheses are Bootstrapped standard errors to account for the generated regressors. \*\* indicates significance at 1-percent level

Figure 2.3 displays the relation between the UIP regression coefficient and the average inflation in the nominal and real terms. Now little difference in the real UIP regression coefficient between the two inflation groups appears. However, in both groups the coefficients are still different from the theoretical parity value of unity.

To illustrate the effects of UIP and relative PPP on exchange rate change, Figure 2.4 displays the plots of the points of exchange rate change, interest rate differential, and expected inflation differential in three-dimensional graphs. For low inflation countries, the covariance of exchange rate change and interest rate differential is higher than the covariance

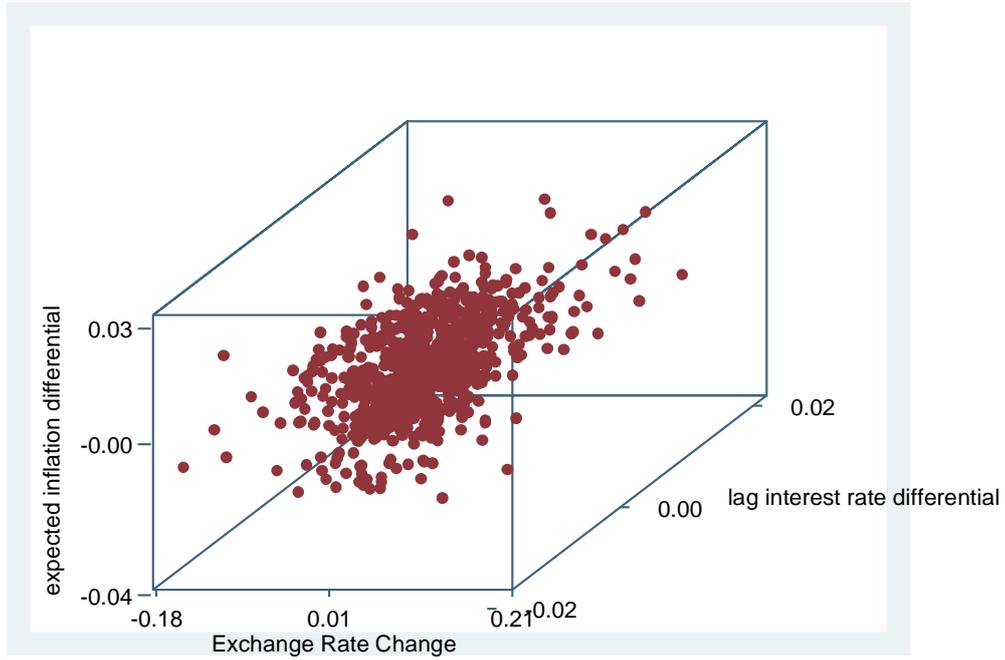
of exchange rate change and expected inflation differential; the opposite is true for high inflation countries. These graphs correspond to the results from the regressions above.



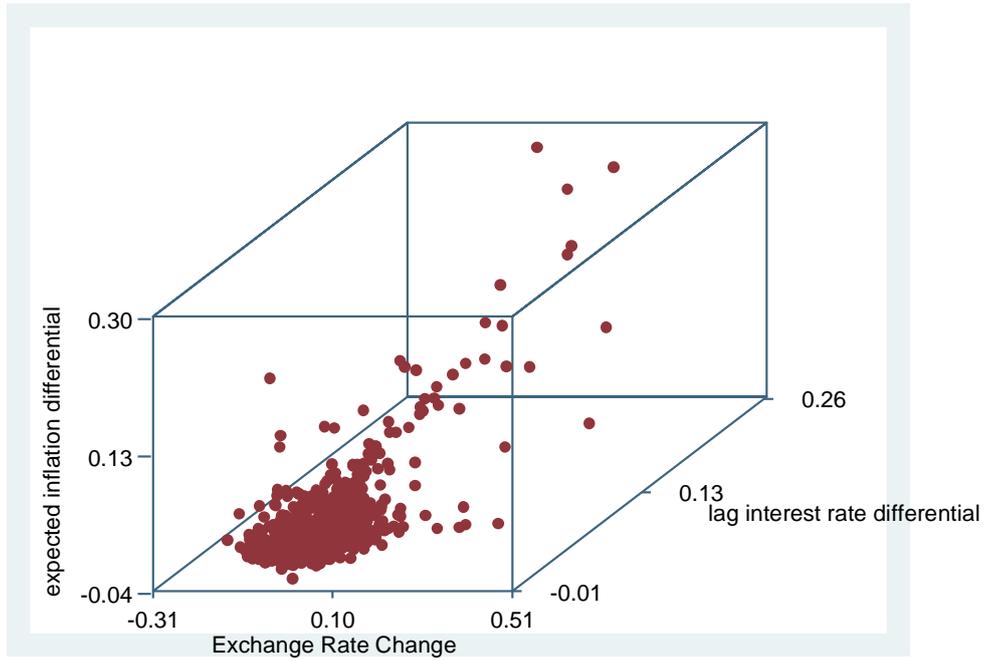
- Notes:
1. Average inflation rates are calculated from quarterly data and then annualized.
  2. Coefficient  $\beta$  is given in regression (2.3) and shown in black.
  3. Coefficient  $b$  is given in regression (2.12) and shown in white.
  4. Country ID is next to each point in figure A above. See Table A 2.1 to determine the identity of each country.

**Figure 2.3: The Nominal vs. Real UIP Regression Coefficients and Average Inflation Rate**

### A. Low Inflation Countries



### B. High Inflation Countries



**Figure 2.4: Exchange Rate Changes, Interest Rate Differentials and Expected Inflation Differentials**

### **2.3.3 Robustness Check**

First, we check the robustness to the subsample period starting in 1997Q3, which is the beginning period used by Burnside, Eichenbaum and Rebelo (2007). In the subsample period, rather than classifying countries into developing and developed groups, we define a low inflation country as one with its average annual inflation rate lower than 2.8%. Countries having an average annual inflation rate higher than 2.8% are classified into high inflation countries. The above two classifications are almost overlapped. Specifically, all developed countries in our subsample have the average inflation rates less than 2.8%. All developing and emerging economy countries in our sample have the average inflation rate higher than 2.8%. Exceptions are Hong Kong and Singapore. Tables A2.2, A2.3, and A2.4 show the regression results of the subsample starting 1997Q3. The results from the subsample period are similar to those of the full-sample period.

Second, we check the robustness to low-high inflation classification criteria. We define extreme inflation cutoffs as follows. All countries having average inflation higher than the 3<sup>rd</sup> Quartile are classified into high-inflation-countries. All countries having average inflation less than the 1<sup>st</sup> Quartile are classified into low-inflation-countries. Tables A2.5, A2.6, and A2.7 present the regression results using the extreme inflation cutoffs. The results using the extreme inflation cutoffs are similar to those of the original regressions.

## **2.4 Conclusion**

Bansal and Dahlquist (2000) found the coefficient of the UIP regression is slightly positive in developing countries. That is, the UIP puzzle is not as extreme as in the developed countries. They argue that the presence of the forward premium is attributed to each country's specific characteristics, especially, average inflation and expected inflation, which are considered as

evidence of segmented markets. Using more recent data, Gilmore and Hayashi (2008) confirmed the findings that the puzzle is less prevalent for emerging market currencies than for major currencies.

A number of studies propose theoretical models with segmented markets to explain the difference between developed and developing countries in the context of UIP. According to these models, when inflation is low, the exchange rate adjustment tends to be slow because adjustment is costly. This is why we observe the UIP puzzle in many developed countries where inflation rates are low

In order to investigate the effect of inflation, rather than classify countries into developed and developing economies, we instead classify them into high inflation and low inflation countries. However, our classification still yields similar groupings of countries as did Bansal and Dahlquist's developed/developing classification (2000) with high inflation overlapping with developing countries and low inflation overlapping with developed countries.

We find that the "nominal puzzle" is less extreme in high inflation countries than in low inflation countries. However, after taking account of the relative PPP effect, we observe the same degree of the real UIP puzzle in both groups of countries. Our empirical investigation suggests that the exchange rate change in the high-inflation group is a result of the relative PPP relation rather than the UIP relation. It appears that the inflation plays a role of a noise rather than a key to unlock the puzzle underlying the UIP relation. If it is the case, we need to focus our investigation on the real relation between the exchange rate changes and the interest rate differentials.

## Chapter 3

### Uncovered Equity Parity: Is It Another Puzzle?

#### 3.1 Introduction

With increases in financial globalization, investors hold foreign risk-free assets or bonds as well as risky-assets such as equities. In the early 1990s, the international equity flows for the U.S. have grown substantially relative to bank loans or government bonds.<sup>11</sup> There is a fundamental theory in international finance based on a no-arbitrage condition in which the interest rate differential between two countries is equal to the expected change in exchange rate, known as the uncovered interest parity (UIP) relation. However, it has long been known that the UIP relation rarely holds empirically.<sup>12</sup>

The increasing portion of international equity flows and the notorious empirical failure of UIP are motivations to explore an alternative no-arbitrage condition in which, instead of the interest rate differential, the expected equity return differential between two countries is equal to the expected change in exchange rate, called the “uncovered equity parity” (UEP) condition. UEP states that when expected foreign equity return is higher than the expected U.S. equity return, rational and risk-neutral U.S. investors should expect the foreign currency to depreciate against the dollar by the difference between the two expected returns. In the literature, UEP is largely supported by data in the sense that the equity return differential predicts exchange rate movement in the right direction. This suggests that UEP holds better than UIP.

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<sup>11</sup> See Hau and Rey (2006).

<sup>12</sup> Engle (1996) provides a comprehensive survey of the literature.

One of the first theoretical and empirical findings in the literature is by Hau and Rey (2006). They develop a model where exchange rates, equity market returns and capital flows are jointly determined. When foreign equity markets outperform domestic equity markets, the relative exposure of domestic investors to exchange rate risk increases. To diminish foreign exchange exposure, the home investor can then rebalance his portfolio decreasing his foreign positions. This will generate capital outflows from the foreign to the domestic country. The foreign capital outflows generated by the risk rebalancing channel will lead to an excess demand for the domestic currency and hence its appreciation. Examining time-series data including ex-post equity returns for seventeen OECD countries, Hau and Rey found support for the model.

Cappiello and De Santis (2005), by employing the Lucas (1982) consumption economy model, propose the UEP relation which is an arbitrage relationship between expected exchange rate changes and expected equity returns differentials of two economies. Specifically, if expected returns on a home equity market are higher than those on foreign markets, investors in the home market suffer a loss when investing abroad. Therefore, they have to be compensated by the expected gain from the foreign currency appreciation. This ensures that arbitrage opportunities do not exist. Using ex-post equity returns for seven developed markets relative to the US market, the found UEP explains a large portion of exchange rate change for some European currencies against the U.S. dollar.

Unlike Hau and Rey's theoretical setup, Cappiello and De Santis (2007) proposed a much simpler model of UEP by extending UIP to risky assets. Using ex-ante equity returns for three European markets relative to the US market, they found that their model was supported by the data for some markets over some periods of time.

Kim (2011) attempts to explain the failure of UEP by extending the UEP model to include the market risk adjustment. He uses the ex-post equity returns data of four Asian emerging markets relative to the U.S., Japan and U.K. He finds evidence to support the hypothesis that there exists market risk in the Asian emerging markets and concludes that the market risk could explain the failure of UEP for those countries. Recently, Curcuru et al. (2014), using ex-post data, investigate the relationship between U.S. investor's portfolio reallocations and returns from investing in forty two foreign countries. They conclude that there exists some evidence supporting UEP.

However, we find problems with testing the UEP relation in the literature, as well as the UIP relation. First, testing the UIP or UEP relation using the UIP or UEP regression tells only whether the relations hold or not. When the relations do not hold, the testing does not intuitively give the magnitude of the deviation of the relation. In addition, the UEP relation should be hold ex-ante not ex-post because economic agents make their probability assessments based on the information available to them at the time. However, the expected equity returns are not known ex ante. If ex-post data are used in the UEP regression, the regression is not valid.

We propose solutions to the above problems as follows. Since the expectation and economic system (data generating process) are not known, we assume that the data are generated according to the ad hoc VAR model. Then we calculate the expected domestic equity return and expected foreign equity return directly and make a comparison. This VAR assumption is necessary because of some benefits. One of the benefits is that ex-ante expectation can be calculated using the underlying distribution. In addition, in the VAR model, each variable is predicted by using the past values of all variables making it a simple exercise. Also, since all time periods are used to calculate the parameters in the VAR,

economic agents know the model and data generating process. So when they make a prediction, they can do it correctly making this a controlled exercise free of prediction errors.

In this paper, we find evidence contrasting most studies in the literature. We show that UIP is less puzzling than UEP. Furthermore, we discover that the UEP regression, used largely in the literature, is a biased predictor of the deviation in UEP. In the next section, we propose the simulation method for testing the UIP and UEP relations. In section 3.3, we report our results. A brief conclusion is given in section 3.4.

## 3.2 Model and Estimation

### 3.2.1 The Uncovered Equity Parity (UEP) condition

Under a no-arbitrage condition, if an investor is risk-neutral, expected domestic equity returns should equal expected foreign equity returns when expressed in common currency. Specifically, when foreign expected equity returns are higher than home expected equity returns, home investors short sell their equity in the home market for one dollar and go long in the foreign equity market by converting that one dollar to foreign currency of  $\frac{1}{S_t}$  to buy foreign equity. After one period, the returns on foreign market will be  $\frac{1}{S_t}E_t(1 + e_{t+1}^*)$  or  $\frac{1}{S_t}E_t[(1 + e_{t+1}^*)S_{t+1}]$  when expressed in home currency. Instead, if that one dollar is invested in the home equity market, the returns after one period will be  $E_t(1 + e_{t+1})$ . To ensure no certain opportunities for profit, the returns from the home and foreign markets should be equal as follows:

$$E_t(1 + e_{t+1}) = \frac{1}{S_t}E_t[(1 + e_{t+1}^*)S_{t+1}], \quad (3.1)$$

where  $e_t$  is a domestic equity return,  $e_t^*$  is a foreign equity return and  $S_t$  is the home currency price of the foreign currency.

Hau and Rey (2006), and Capiello and De Santis (2005), among others, test the UEP relation in a way similar to testing the UIP relation. Equity return differential is used instead of interest rate differential giving the UEP regression as follows:

$$\Delta s_{t+1} = \alpha_0 + \alpha_1(e_{t+1} - e_{t+1}^*) + v_{t+1}. \quad (3.2)$$

where  $\Delta = 1 - L$ ,  $s_t = \log S_t$ .

They find that, unlike the UIP regression, the estimated slope coefficients are slightly positive (less than unity) for most countries and pooled data. Therefore, they conclude that high equity returns currencies tend to depreciate against low equity returns currencies.

However, equation (3.1) can be rewritten as

$$E_t(1 + e_{t+1}) = E_t[(1 + e_{t+1}^*)]E_t\left(\frac{S_{t+1}}{S_t}\right) + Cov_t\left(1 + e_{t+1}^*, \frac{S_{t+1}}{S_t}\right), \quad (3.1')$$

Due to the covariance term, we cannot express the UEP relation in a regression model. In addition to the above problem, testing the UIP or UEP relation using the UIP or UEP regression tells only whether the relations hold or not. When the relations do not hold, the testing does not intuitively give the magnitude of the deviation of the relation. Lastly, the UEP relation should hold ex-ante not ex-post because economic agents make their probability assessments based on the information available to them at the time. If ex-post data are used in the UEP regression, the error term is correlated with the regressor.

We propose solutions to the above problems as follows. We calculate the expected domestic equity return and expected foreign equity return directly and make a comparison. Since the expectation and economic system (data generating process) are not known, we assume that the data are generated according to the ad hoc VAR model.

### 3.2.2 Estimation

We propose an alternative method to test UEP. First, we define the ratio from the UEP relation as

$$UEPR_{t+1} = \frac{E_t[(1+e_{t+1}^*)S_{t+1}]}{E_t(1+e_{t+1})S_t} \quad (3.3)$$

where,  $UEPR_{t+1}$  is the UEP ratio.

UEP holds if  $UEPR_{t+1} = 1$ . Second, we assume that economic agents behave as the VAR model. Therefore, data are generated by fitting the three-variable VAR model consisting of variables  $e_t$ ,  $e_t^*$ , and  $S_t$ .

Similarly, we define the ratio from the UIP condition as the ratio of foreign returns on the bond market and domestic returns on the bond market:

$$UIPR_t = \frac{(1+i_t^*)E_t(S_{t+1})}{S_t(1+i_t)}, \quad (3.4)$$

where,  $UIPR_t$  is the UIP ratio.

We also assume that the data are generated by fitting the three-variable VAR model consisting of variables  $i_t$ ,  $i_t^*$ , and  $S_t$ .

### 3.2.3 The Data Generating Processes

To test the UEP relation, the VAR model is assumed as the data generating process. The simulations are run 500 times. The number of lags is determined by the Schwarz's Bayesian information criterion (SBIC).

Consider the VAR presentation:

$$y_{t_{3 \times 1}} = X_{t_{3 \times 3(3P+1)}} \beta_{3(3p+1) \times 1} + \varepsilon_{t_{3 \times 1}}, \quad (3.5)$$

where

$$y_t = \begin{bmatrix} y_{1t} \\ y_{2t} \\ y_{3t} \end{bmatrix}_{3 \times 1} = \begin{bmatrix} e_t \\ e_t^* \\ S_t \end{bmatrix}_{3 \times 1}$$

$$X_t = I_{3 \times 3} \otimes [1 \ y'_{t-1 \times 3} \ \dots \ y'_{t-p \times 3}]_{1 \times (3p+1)}$$

$$\beta = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix}_{3(3p+1) \times 1}, \text{ where } \beta_i = \begin{bmatrix} c^i \\ b_{\cdot 1}^i \\ b_{\cdot 2}^i \\ \vdots \\ b_{\cdot p}^i \end{bmatrix}_{(3p+1) \times 1}, \quad i = 1, 2, 3, \text{ and } c^i \text{ is a constant.}$$

$$b_{\cdot j}^i = \begin{bmatrix} b_{1j}^i \\ b_{2j}^i \\ b_{3j}^i \end{bmatrix}_{3 \times 1}, \quad j = 1, 2, \dots, p.$$

$$\varepsilon_t = \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix}_{3 \times 1}$$

The data and empirical distribution of  $UEPR_{t+1}$  are created as follows:

Step 1. Use the original data to get the coefficient estimates,  $\hat{\beta}$  and  $\hat{\Sigma}$ .

Step 2. Draw  $\varepsilon_t$  from multivariate normal distribution based on the estimated covariance matrix:  $\varepsilon_t \sim \mathcal{N}(0, \hat{\Sigma})$ .

Step 3. Generate new observations based on the assumed data generated process as follows:

Fix the initial observation to the value of the original observed data up to the  $p^{th}$  period ( $p$  is the number of lags).

Use the coefficient estimate,  $\hat{\beta}$ , in step 1 to generate systematic part of  $X_t \hat{\beta}$ , then add  $\varepsilon_t$  to

get  $\begin{bmatrix} e_t \\ e_t^* \\ S_t \end{bmatrix}$ .

Step 4. Given  $\varepsilon_t$  already drawn, draw additional  $\varepsilon_t^+$  as explained in step 2 to generate additional  $e_{t+1}^+$  and  $S_{t+1}^+$  in each of the time period from period  $p + 1$ . Repeat this step 500 times. Then calculate  $\frac{1}{500} \sum_{i=1}^{500} e_{t+1}^{*+i} S_{t+1}^{+i}$  to obtain  $E_t(e_{t+1}^* S_{t+1})$ .

Step 5. Calculate each period UEP ratio:  $UEPR_{t+1} = \frac{E_t[(1+e_{t+1}^*)S_{t+1}]}{E_t(1+e_{t+1})S_t}$ . Then average them over time.

Step 6. To get the empirical distribution, Repeat Step 2, 3, 4, and 5 500 times.

In the same fashion, to test the UIP relation, the VAR representation (3.5) is also

assumed, but  $y_t = \begin{bmatrix} i_t \\ i_t^* \\ S_t \end{bmatrix}_{3 \times 1}$  instead. The data and empirical distribution of  $UIPR_{t+1}$  are

similarly created as follows:

Step 1. Use the original data to get the coefficient estimates,  $\hat{\beta}$  and  $\hat{\Sigma}$ .

Step 2. Draw  $\varepsilon_t$  from multivariate normal distribution based on the estimated covariance matrix:  $\varepsilon_t \sim \mathcal{N}(0, \hat{\Sigma})$ .

Step 3. Generate new observations based on the assumed data generated process as follows:

Fix the initial observation to the value of the original observed data up to the  $p^{th}$  period ( $p$  is the number of lags).

Use the coefficient estimate,  $\hat{\beta}$ , in step 1 to generate systematic part of  $X_t \hat{\beta}$ , then add  $\varepsilon_t$  to

get  $\begin{bmatrix} i_t \\ i_t^* \\ S_t \end{bmatrix}$ .

Step 4. Calculate each period UEP ratio:  $UIPR_t = \frac{(1+i_t^*)E_t(S_{t+1})}{S_t(1+i_t)}$ . Then average them over time.

Step 5. To get the empirical distribution, Repeat Step 2, 3 and 4 500 times.

Above we elaborated how we obtain the empirical distributions and calculate the UEP ratio and UIP ratio directly from the definitions. However, since most studies use the regression models to test the parities, we would like to see how the regressions perform in our alternative testing method. , we translate the regressions into the Ratios by calculating the UEP Ratio and UIP Ratio implied by the regressions as follows.

## UEP Ratio implied by regression

Consider the UEP regression:

$$\Delta S_{t+1} = \alpha_0 + \alpha_1(E_t(e_{t+1}) - E_t(e_{t+1}^*)) + v_{t+1}, \quad (3.6)$$

$$\text{or } E_t(\Delta S_{t+1}) = \hat{\alpha}_0 + \hat{\alpha}_1(E_t(e_{t+1}) - E_t(e_{t+1}^*)).$$

$$UEPR_{t+1} = \frac{E_t[(1+e_{t+1}^*)S_{t+1}]}{E_t(1+e_{t+1})S_t},$$

where,  $UEPR_{t+1}$  is the UEP ratio.

$$UEPR_{t+1} = \exp \{ \log E_t(1 + e_{t+1}^*) + \log E_t(S_{t+1}) - \log E_t(1 + e_{t+1}) - \log(S_t) + \psi_{t+1} \},$$

$$\text{where, } \psi_{t+1} = \log E_t[(1 + e_{t+1}^*)S_{t+1}] - \log[E_t(1 + e_{t+1}^*)E_t(S_{t+1})] = \text{Cov}_t(1 + e_{t+1}^*, \frac{S_{t+1}}{S_t}).$$

$$UEPR_{t+1} =$$

$$\exp \{ E_t \log(1 + e_{t+1}^*) + \varphi_{2t+1} + \log E_t(S_{t+1}) + \varphi_{1t+1} - E_t \log(1 + e_{t+1}) - \varphi_{3t+1} - \log(S_t) + \psi_{t+1} \},$$

where,  $\varphi_{1t+1} = \log E_t(S_{t+1}) - E_t \log(S_{t+1})$ ,  $\varphi_{2t+1} = \log E_t(1 + e_{t+1}^*) - E_t \log(1 + e_{t+1}^*)$ ,  $\varphi_{3t+1} = \log E_t(1 + e_{t+1}) - E_t \log(1 + e_{t+1})$ .  $\varphi_{1t+1}$ ,  $\varphi_{2t+1}$ , and  $\varphi_{3t+1}$  are the Jensen's Inequality terms.

$$UEPR_{t+1} = \exp \{ E_t(e_{t+1}^*) + E_t(\Delta S_{t+1}) - E_t(e_{t+1}) + \varphi_{1t+1} + \varphi_{2t+1} - \varphi_{3t+1} + \psi_{t+1} \}.$$

$$= \exp \{ E_t(e_{t+1}^*) - E_t(e_{t+1}) + \hat{\alpha}_0 + \hat{\alpha}_1(E_t(e_{t+1}) - E_t(e_{t+1}^*)) + \varphi_{1t+1} + \varphi_{2t+1} - \varphi_{3t+1} + \psi_{t+1} \}.$$

$$= \exp \{ \hat{\alpha}_0 + (\hat{\alpha}_1 - 1)(E_t(e_{t+1}) - E_t(e_{t+1}^*)) + \varphi_{1t+1} + \varphi_{2t+1} - \varphi_{3t+1} + \psi_{t+1} \}. \quad (3.7)$$

## Simulation Method

Step 1. Use the original data to get the coefficient estimates,  $\hat{\beta}$  and  $\hat{\Sigma}$ .

Step 2. Draw  $\varepsilon_t$  from multivariate normal distribution based on the estimated covariance matrix:  $\varepsilon_t \sim \mathcal{N}(0, \hat{\Sigma})$ .

Step 3. Generate new observations based on the assumed data generated process as follows:

Fix the initial observation to the value of the original observed data up to the  $p^{th}$  period ( $p$  is the number of lags).

Use the coefficient estimate,  $\hat{\beta}$ , in step 1 to generate systematic part of  $X_t \hat{\beta}$ , then add  $\varepsilon_t$  to

$$\text{get } \begin{bmatrix} e_t \\ e_t^* \\ S_t \end{bmatrix}.$$

Step 4. Run the UIP regression to estimate  $\alpha_1$ .

Step 5. Calculate each period UEP Ratio implied by regression:  $\exp\{\hat{\alpha}_0 + (\hat{\alpha}_1 - 1)(E_t(e_{t+1}) - E_t(e_{t+1}^*))\}$ , the covariance term  $\exp(\psi_{t+1})$ , the Jensen's Inequality terms  $\exp(\varphi_{1t+1})$ ,  $\exp(\varphi_{2t+1})$ , and  $\exp(\varphi_{3t+1})$ . Then average them over time.

Step 6. To get the empirical distribution, Repeat Step 2, 3, 4, and 5 500 times.

## UIP Ratio implied by the regression

Consider UIP regression:

$$\Delta s_{t+1} = \theta_0 + \theta_1(i_t - i_t^*) + u_{t+1}, \quad (3.8)$$

or  $E_t(\Delta s_{t+1}) = \hat{\theta}_0 + \hat{\theta}_1(i_t - i_t^*)$ .

$$UIPR_t = \frac{(1+i_t^*)E_t(S_{t+1})}{S_t(1+i_t)},$$

where  $UIPR_t$  is the UIP Ratio.

$$UIPR_t = \exp \{ \log(1 + i_t^*) + \log E_t(S_{t+1}) - \log(S_t) - \log(1 + i_t) \}.$$

$$= \exp \{ i_t^* + E_t(\Delta s_{t+1}) + \varphi_{t+1} - i_t \},$$

where the Jensen's Inequality term  $\varphi_{t+1} = \log E_t(S_{t+1}) - E_t(\log(S_{t+1}))$ .

$$UIPR_t = \exp \{ i_t^* + \hat{\theta}_0 + \hat{\theta}_1(i_t - i_t^*) - i_t + \varphi_{t+1} \}.$$

$$= \exp \{ \hat{\theta}_0 + (\hat{\theta}_1 - 1)(i_t - i_t^*) + \varphi_{t+1} \}. \quad (3.9)$$

## Simulation Method

Step 1. Use the original data to get the coefficient estimates,  $\hat{\beta}$  and  $\hat{\Sigma}$ .

Step 2. Draw  $\varepsilon_t$  from multivariate normal distribution based on the estimated covariance matrix:  $\varepsilon_t \sim \mathcal{N}(0, \hat{\Sigma})$ .

Step 3. Generate new observations based on the assumed data generated process as follows:

Fix the initial observation to the value of the original observed data up to the  $p^{th}$  period ( $p$  is the number of lags).

Use the coefficient estimate,  $\hat{\beta}$ , in step 1 to generate systematic part of  $X_t\hat{\beta}$ , then add  $\varepsilon_t$  to

$$\text{get} \begin{bmatrix} i_t \\ i_t^* \\ S_t \end{bmatrix}.$$

Step 4. Run the UIP regression to estimate  $\theta_1$ .

Step 5. Calculate each period UEP deviation:  $\exp \{ \hat{\theta}_0 + (\hat{\theta}_1 - 1)(i_t - i_t^*) + \varphi_{t+1} \}$ . Then average them over time.

Step 6. To get the empirical distribution, Repeat Steps 2, 3, 4, and 5 500 times.

### 3.3 Results

#### 3.3.1 Data

The data in this empirical investigation are quarterly data on exchange rates and equity price index in nine countries with developed financial markets over the third quarter of 1997 through the first quarter of 2007. The exchange rate in each country is the price of each currency in terms of US dollars.<sup>13</sup>

#### 3.3.2 UEP vs. UIP

Table 3.1 shows the central tendency of the UIP Ratio, UEP Ratio, and their standard deviations. The central tendency of the UIP Ratio is just slightly different from unity for every country. For example, the central tendency of the UIP Ratio for Australia is 1.002 indicating that the return from Australian (foreign) assets is just 0.2 percent higher than the

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<sup>13</sup> The data on daily spot exchange rates are from the Datastream of the WM Company/Reuters, except the euro, which is from Barclay's Bank International. The equity price index data are from the Datastream.

return from U.S. (home) assets. In other words, UIP holds better than we thought, given the negative coefficient estimate in the UIP regression or the UIP puzzle often found in the literature. In addition, it is surprising that the central tendency of the UIP Ratio is significantly less than the central tendency of the UEP Ratio for every country. So, we find that UIP holds better than UEP. This notion is opposite from the literature that mostly finds evidence supporting UEP not UIP. However, it is not clear whether the equity carry trade is riskier than the currency carry trade since, unlike others, the standard deviations of UIP Ratio for Denmark, New Zealand, and Switzerland are greater than those of UEP Ratio.

**Table 3.1: UIP Ratio and UEP Ratio**

Country	UIPR (1)	UIPR C.I. (2)	UIPR Std (3)	UEPR (4)	UEPR C.I. (5)	UEPR Std (6)
Australia	1.002	(1.000, 1.004)	0.025	1.060	(1.056, 1.064)	0.046
Canada	1.018	(1.013, 1.023)	0.055	1.122	(1.116, 1.129)	0.075
Denmark	1.057	(1.049, 1.065)	0.091	1.156	(1.150, 1.161)	0.064
Euro	1.008	(1.004, 1.012)	0.045	1.179	(1.173, 1.185)	0.067
Japan	0.995	(0.993, 0.997)	0.023	1.034	(1.030, 1.038)	0.049
New Zealand	1.017	(1.011, 1.023)	0.071	1.044	(1.040, 1.047)	0.040
Norway	1.038	(1.032, 1.044)	0.067	1.156	(1.150, 1.162)	0.067
Sweden	1.034	(1.028, 1.039)	0.061	1.194	(1.188, 1.200)	0.065
Switzerland	1.036	(1.029, 1.042)	0.074	1.053	(1.050, 1.056)	0.037
United Kingdom	0.987	(0.984, 0.990)	0.038	1.105	(1.101, 1.109)	0.045

Note: 1. Columns 1 and 2 show the mean of the UIP Ratio and its 95% confidence interval.  
2. Column 3 shows the standard deviation of the UIP Ratio.  
3. Columns 4 and 5 show the mean of the UEP Ratio and its 95% confidence interval.  
4. Column 6 shows the standard deviation of the UEP Ratio

Why do we find such contrasting results from the literature? Most researchers employ the UIP regression to test the UIP relation and the UEP regression to test the UEP relation. However, when the relations do not hold, the testing does not intuitively give the magnitude of the deviation of the relations. So, one of the benefits of using the UIP Ratio and UEP Ratio is that this testing can tell the degree of the deviation from the parities.

Figure 3.1 illustrates the empirical distributions of the UIP Ratio and UEP Ratio corresponding to the results in Table 3.1. Most empirical distributions are normally distributed except those of the UIP Ratio for Denmark, Norway, Sweden, and Switzerland which are bimodally distributed. For these countries, their interest rates fluctuate around U.S. interest rate, so the returns of currency carry trade alternate between positive and negative.

Since most of the literature relies on the regression methods to test the parities, we are interested to compare and contrast the UIP Ratio and UIP Ratio implied by the regressions from the Ratios calculated directly from the definitions. Table 3.2 shows the central tendency of the UIP Ratio, UIP Ratio implied by the regression, and the Jensen's Inequality term. It is clear that the central tendencies of the UIP Ratio and UIP Ratio implied by the regression are similar. Regarding the Jensen's Inequality term which is always left out from the regression, the central tendency of its exponential is near unity. In other words, the Jensen's Inequality term is close to zero for each country. So we have the impression that the UIP regression can be an unbiased predictor of the UIP relation.

**Table 3.2: UIP Ratio Implied by the Regression**

Country	UIPR (1)	UIPR C.I. (2)	UIPR by regress (3)	UIPR by regress C.I. (4)	$exp(\psi)$ (5)	$exp(\psi)$ C.I. (6)
Australia	1.002	(1.000, 1.004)	0.996	(0.994, 0.998)	1.006	(1.005, 1.006)
Canada	1.018	(1.013, 1.023)	1.015	(1.010, 1.020)	1.003	(1.003, 1.004)
Denmark	1.057	(1.049, 1.065)	1.049	(1.041, 1.057)	1.007	(1.007, 1.008)
Euro	1.008	(1.004, 1.012)	1.002	(0.998, 1.006)	1.007	(1.006, 1.007)
Japan	0.995	(0.993, 0.997)	0.992	(0.990, 0.994)	1.004	(1.003, 1.004)
New Zealand	1.017	(1.011, 1.023)	1.001	(0.996, 1.006)	1.013	(1.013, 1.014)
Norway	1.038	(1.032, 1.044)	1.031	(1.026, 1.037)	1.006	(1.006, 1.007)
Sweden	1.034	(1.028, 1.039)	1.027	(1.021, 1.032)	1.007	(1.006, 1.007)
Switzerland	1.036	(1.029, 1.042)	1.029	(1.023, 1.036)	1.006	(1.006, 1.007)
United Kingdom	0.987	(0.984, 0.990)	0.985	(0.982, 0.989)	1.002	(1.001, 1.002)

Note: 1. Columns 1 and 2 show the mean of the UIP Ratio calculated directly from the definition and its 95% confidence interval.

2. Columns 2 and 3 show the mean of the UIP Ratio implied by the regression and its 95% confidence interval.

3. Columns 5 and 6 show the central tendency of exponential of the Jensen's Inequality term and its 95% confidence interval.

Figure A3.2 illustrates the empirical distribution of the UIP Ratio implied by the regressions and exponential of the Jensen's Inequality Term corresponding to results in Table 3.2. Most empirical distributions are normally distributed except those of the UIP Ratio for Denmark, Norway, Sweden, and Switzerland which are bimodally distributed. For these countries, their interest rates fluctuate around the U.S. interest rate, so the returns of currency carry trade alternate between positive and negative.

Similarly, we contrast the UEP Ratio and UEP Ratio implied by the regressions from the Ratios calculated directly from the definitions. Table 3.3 shows the central tendency of the UEP Ratio, UEP Ratio implied by the regression, the covariance of foreign equity return and exchange rate, and the Jensen's Inequality terms. By comparing columns 1 and 3, we find

that the UEP Ratio implied by the regression is significantly less than the UEP Ratio calculated directly from the definition. This suggests that the UEP regression is a bias predictor of the UEP relation. In order to investigate where the bias is from, we calculate the terms that are usually left out from the regression: the covariance of foreign equity return and exchange rate, and the Jensen's Inequality terms. Columns 5, 7, 9 and 11 show the central tendency of the exponential of the covariance term and Jensen's Inequality terms, respectively. We find that the covariance term is far from zero (its exponential is far from unity). However, the Jensen's Inequality terms are relatively small and close to zero. Now we have the impression that the bias from the UEP regression comes from the ignorance of the covariance term. The positive covariance term suggests that when the foreign equity return increases, demand of the foreign currency rises making the foreign currency appreciate. This is why the expected foreign equity return is greater than the expected domestic equity return in our model.

Figure A3.3 shows empirical distributions of the UEP Ratio implied by the regression, exponentials of the covariance term and the Jensen's Inequality terms. All empirical distributions are normally distributed.

**Table 3.3: UEP Ratio Implied by the Regression**

Country	UEPR	UEPR C.I.	UEPR by regress	UEPR by regress C.I.	exp( $\psi$ )	exp( $\psi$ ) C.I.
	(1)	(2)	(3)	(4)	(5)	(6)
Australia	1.060	(1.056, 1.064)	1.012	(1.007, 1.017)	1.046	(1.044, 1.047)
Canada	1.122	(1.116, 1.129)	1.029	(1.022, 1.036)	1.089	(1.086, 1.091)
Denmark	1.156	(1.150, 1.161)	1.043	(1.036, 1.051)	1.107	(1.103, 1.111)
Euro	1.179	(1.173, 1.185)	1.043	(1.036, 1.051)	1.134	(1.129, 1.140)
Japan	1.034	(1.030, 1.038)	1.013	(1.008, 1.017)	1.020	(1.019, 1.022)
New Zealand	1.044	(1.040, 1.047)	1.028	(1.024, 1.033)	1.012	(1.011, 1.013)
Norway	1.156	(1.150, 1.162)	1.039	(1.032, 1.046)	1.111	(1.107, 1.115)
Sweden	1.194	(1.188, 1.200)	1.041	(1.035, 1.048)	1.147	(1.141, 1.152)
Switzerland	1.053	(1.050, 1.056)	1.001	(0.996, 1.006)	1.053	(1.050, 1.055)
United Kingdom	1.105	(1.101, 1.109)	1.008	(1.003, 1.013)	1.097	(1.094, 1.101)

**Table 3.3: UEP Ratio Implied by the Regression (Continued)**

Country	exp( $\varphi_1$ )	exp( $\varphi_1$ ) C.I.	exp( $\varphi_2$ )	exp( $\varphi_2$ ) C.I.	exp( $\varphi_3$ )	exp( $\varphi_3$ ) C.I.
	(7)	(8)	(9)	(10)	(11)	(12)
Australia	1.010	(1.009, 1.011)	1.004	(1.003, 1.005)	1.010	(1.008, 1.011)
Canada	0.996	(0.995, 0.997)	1.014	(1.012, 1.016)	1.007	(1.006, 1.009)
Denmark	0.998	(0.997, 0.999)	1.019	(1.016, 1.021)	1.013	(1.011, 1.015)
Euro	0.978	(0.976, 0.980)	1.033	(1.030, 1.037)	1.010	(1.008, 1.012)
Japan	0.997	(0.996, 0.999)	1.010	(1.009, 1.012)	1.003	(1.002, 1.004)
New Zealand	1.006	(1.005, 1.006)	1.002	(1.001, 1.002)	1.004	(1.003, 1.005)
Norway	0.984	(0.982, 0.985)	1.028	(1.025, 1.031)	1.008	(1.007, 1.010)
Sweden	0.964	(0.962, 0.967)	1.050	(1.046, 1.053)	1.014	(1.012, 1.015)
Switzerland	1.001	(1.000, 1.002)	1.008	(1.006, 1.010)	1.007	(1.006, 1.009)
United Kingdom	0.999	(0.999, 1.000)	1.020	(1.018, 1.023)	1.017	(1.015, 1.020)

- Note:
1. Columns 1 and 2 show the mean of the UEP Ratio calculated directly from the definition and its 95% confidence interval.
  2. Columns 2 and 3 show the mean of the UEP Ratio implied by the regression and its 95% confidence interval.
  3. Columns 5 and 6 show the central tendency of exponential of  $\psi_{t+1} = \log E_t[(1 + e_{t+1}^*)S_{t+1}] - \log[E_t(1 + e_{t+1}^*)E_t(S_{t+1})]$  and its 95% confidence interval.
  4. Columns 7 and 8 show the central tendency of exponential of the Jensen's Inequality term  $\varphi_{1t+1} = \log E_t(S_{t+1}) - E_t \log(S_{t+1})$  and its 95% confidence interval.
  5. Columns 9 and 10 show the central tendency of exponential of the Jensen's Inequality term  $\varphi_{2t+1} = \log E_t(1 + e_{t+1}^*) - E_t \log(1 + e_{t+1}^*)$  and its 95% confidence interval.
  6. Columns 11 and 12 show the central tendency of exponential of the Jensen's Inequality term  $\varphi_{3t+1} = \log E_t(1 + e_{t+1}) - E_t \log(1 + e_{t+1})$  and its 95% confidence interval.

### 3.4 Conclusion

The UIP regression has long been used to test the UIP relation. Recently, Hau and Rey (2006), Cappiello and De Santis (2005), and Kim (2011) modify the UIP regression to replace the returns from risk-free assets such as T-bills with the expected returns from risky assets such as equity. It is called the UEP regression, and it has been used to test the UEP relation, an arbitrage condition in equity markets. In this paper, we find problems with the regression method used to test the existence of the parities. First, the regression method does not intuitively give the magnitude of deviation when the UIP or UEP relation does not hold. In addition, the UEP relation should be hold ex-ante not ex-post. However, the expected equity returns are not known ex ante. If ex-post data are used in the UEP regression [as done by Hau and Rey (2006), Cappiello and De Santis (2005), and Kim (2011)], the regression is not valid

Due to the shortcomings of the regression method, we propose an alternative method to test the UIP relation and UEP relation called the UIP Ratio and UEP Ratio, respectively, by the simulation technique. We come up with four main findings. First, UIP is less puzzling than we thought since the UIP regression does not intuitively give the magnitude of the deviation in UIP. Second, unlike the literature, we find that UIP holds better than UEP. Third, the UEP regression is a bias predictor of the deviation in UEP because the covariance of foreign equity return and exchange rate is left out. Finally, the expected foreign equity return is greater than the expected domestic equity return in our model. The reason is that  $Cov_t(e_{t+1}^*, S_{t+1})$  is positive ( $\varphi_{1t+1} > 0$ ). When the foreign equity return increases, demand for the foreign currency rises making the foreign currency appreciate.

## Chapter 4

### Summary

Uncovered interest parity (UIP) is a no-arbitrage condition in the asset market where trades are instantaneous and virtually frictionless. UIP explains an equilibrium in which a speculator is indifferent between interest bearing identical assets denominated in different currency. UIP predicts that a high interest currency tends to depreciate against a low interest rate currency by the same percentage point as the interest rate differential between the two countries. Empirically, when the exchange rate change is regressed on the interest rate differential the null hypothesis that the slope coefficient is unity should not be rejected.

It is important to emphasize that empirically, the exchange rate change can be predicted by not only the interest rate differential but also the inflation differential via the relative PPP relation. Relative PPP is an equilibrium in the goods market. Relative PPP predicts that a high-inflation currency tends to depreciate against a low-inflation currency. To test relative PPP, the exchange rate change is regressed on the inflation differential. Therefore, it is crucial to distinguish whether the exchange rate change is due to the asset market (UIP relation) or goods market (relative PPP relation).

It has long been known that the uncovered interest parity (UIP) relation rarely holds empirically. Most studies use the data from developed economies and find that the UIP slope coefficient is often not only less than unity but also negative. However, when data from emerging economies are used, the UIP slope coefficient is not negative (though still far from unity). In other words, according to these findings, the UIP relation is less puzzling for emerging economies. In this dissertation, we attempt to answer the following question: are

the economies of developing countries different from those of developed countries in the context of the UIP condition?

In Chapter 2, we find that low inflation countries (most are developed countries) and high inflation countries (all are developing countries) are different in context of nominal UIP. That is, the “nominal UIP puzzle” is less prevalent in high inflation countries than in low inflation countries. However, regarding the real UIP relation, the two groups of countries are similar. Specifically, the low inflation countries have the same degree of “real UIP puzzle” as the high inflation countries. This is the broad contribution of Chapter 2. We argue that the exchange rate change in high-inflation countries is due to the relative PPP relation, not the UIP relation as in low-inflation countries. It appears that the inflation plays a role of a noise in rather than a key to unlock the puzzle underlying the UIP relation. If this is the case, future research should focus on the real UIP relation. In addition, more research should investigate and explain the “real UIP puzzle.”

With increases in financial globalization, investors hold foreign risk-free assets or bonds as well as risky-assets such as equities. The increasing portion of international equity flows and the notorious empirical failure of UIP are motivations to explore an alternative no-arbitrage condition in which, instead of interest rate differential, expected equity return differential between two countries is equal to expected change in exchange rate, called the “uncovered equity parity” (UEP) condition. UEP states that when expected foreign equity return is higher than the expected U.S. equity return, rational and risk-neutral U.S. investors should expect the foreign currency to depreciate against the dollar by the difference between the two expected returns. In the literature, UEP is largely supported by data in the sense that equity return differential predicts exchange rate movement in the right direction. This suggests that UEP holds better than UIP.

In Chapter 3, we find problems with the regression method used to test the UIP or UEP relation. First, the regression method does not intuitively give the magnitude of deviation when the UIP or UEP relation does not hold. In addition, the UEP relation should be hold ex-ante not ex-post. However, the expected equity returns are not known ex ante. We propose an alternative method to test UIP and UEP. This is the broad contribution of Chapter 3. Our method intuitively gives the magnitude of the deviation from the parities. With shortcomings of conventional UIP and UEP testing using the regressions, we find that UIP actually holds better than UEP. Furthermore, we find that the UEP regression is a bias predictor of the deviation in UEP because the covariance of foreign equity return and exchange rate is left out. In future research, we should investigate why the arbitrage in the assets market via UIP holds better than the arbitrage in the equity markets via UEP.

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## Appendix

**Table A 2.1: Country Information**

ID	Country	Start Date	End Date	Inflation Group	Interest Source	Rate	Unemployment Rate Source
1	Argentina	1997q4	2009q1	H	DS	-	
2	Australia	1997q3	2009q1	L	DS		OECD
3	Austria	1994q1	1998q4	L	DS		OECD
4	Belgium	1994q1	1998q4	L	DS		OECD
5	Brazil	2000q1	2009q1	H	GFD		OECD
6	Canada	1994q1	2009q1	L	DS		OECD
7	Colombia	2001q3	2008q1	H	GFD		IMF
8	Croatia	1997q4	2006q2	H	DS		-
9	Czech Republic	1995q2	2009q1	H	DS		OECD
10	Denmark	1994q1	2009q1	L	DS		-
11	Eurozone	1999q2	2009q1	L	DS		OECD
12	Finland	1994q1	1998q4	L	DS		OECD
13	France	1994q1	1998q4	L	DS		OECD
14	Germany	1994q1	1998q4	L	DS		OECD
15	Greece	1994q4	2000q4	H	DS		-
16	Hong Kong	1997q3	2009q1	L	DS		IMF
17	Hungary	1996q1	2009q1	H	DS		OECD
18	Iceland	1998q4	2007q4	H	DS		-
19	India	1999q3	2009q1	H	DS		-
20	Indonesia	1997q3	2009q1	H	GFD		-
21	Ireland	1994q1	1998q4	L	DS		OECD
22	Italy	1994q1	1998q4	L	DS		OECD
23	Japan	1994q1	2009q1	L	DS		OECD
24	Mexico	2001q4	2009q1	H	DS		OECD
25	Netherlands	1994q1	1998q4	L	DS		-
26	New Zealand	1997q3	2009q1	L	DS		OECD
27	Norway	1994q1	2009q1	L	DS		OECD
28	Pakistan	1994q2	2009q1	H	DS		-
29	Philippines	1999q4	2006q3	H	DS		IMF
30	Poland	1994q2	2009q1	H	DS		OECD
31	Portugal	1994q1	1998q4	L	DS		IMF
32	Romania	1997q3	2009q1	H	DS		-
33	Russia	1996q3	2009q1	H	DS		-
34	Singapore	1994q1	2009q1	L	DS		-
35	Slovakia	1997q3	2008q4	H	DS		OECD
36	South Africa	1997q3	2009q1	H	DS		-
37	Spain	1994q1	1998q4	L	DS		OECD
38	Sweden	1997q3	2009q1	L	DS		OECD
39	Switzerland	1994q1	2009q1	L	BBA		OECD
40	Thailand	1997q3	2006q3	H	DS		-
41	Turkey	2003q1	2009q1	H	DS		OECD
42	United Kingdom	1994q1	2009q1	L	DS		OECD

Note: L and H indicate low and high inflation countries, respectively. DS, GFD and BBA stand for the Datastream, the Global Financial Data and the British Bankers' Association, respectively. IMF data was obtained from the International Monetary Fund's International Financial Statistics CD released for June 2009. OECD data was retrieved from <http://stats.oecd.org/>.

**Table A 2.2: Nominal UIP Regressions (1997Q3-2009Q1)**

Independent Variable	Low Inflation	High Inflation	Low Inflation	High Inflation
	$\Delta s_{t+1}$ (1)	$\Delta s_{t+1}$ (2)	$\Delta s_{t+1}$ (3)	$\Delta s_{t+1}$ (4)
<i>A. Fixed Effects Regression</i>				
$i_t - i_t^*$	-1.549** (0.333)	0.403* (0.192)	-1.569** (0.323)	-0.200 (0.392)
$\pi_{t+1}^e - \pi_{t+1}^{*e}$			0.096 (0.414)	0.847** (0.283)
$R^2$	0.014	0.019	0.014	0.059
$N$	617	846	855	855

**B. Hypothesis Testing**

Null Hypothesis	$t$ -statistic	$p$ -value
$\beta_L = 1$	7.66**	0.000
$\beta_H = 1$	3.10**	0.001
$\beta_L = \beta_H$	5.08**	0.000
$\beta_{1L} = \beta_{1H}$	2.70**	0.001

*Notes:* 1. Nominal UIP is given in regression (2):  $\Delta s_{t+1} = \beta_{0i} + \beta_i(i_t - i_t^*) + u_{t+1}$ ; and the augmented UIP is given in regression (2.8):  $\Delta s_{t+1} = \tilde{\beta}_i + \beta_{1i}(i_t - i_t^*) + \beta_{2i}(\pi_{t+1}^e - \pi_{t+1}^{*e}) + \tilde{u}_{t+1}$ , where  $i = L$  for low inflation countries and  $i = H$  for high inflation countries.  
2. The hypothesis testing is performed using the two-tailed test.  
3. Numbers in parentheses are robust standard errors for regression (2.3) and are Bootstrapped standard errors to account for the generated regressor in regression (2.5). \* indicates significance at 5-percent level. \*\* indicates significance at 1-percent level.

**Table A 2.3: Relative PPP Regressions (1997Q3-2009Q1)**

Independent Variable	Low Inflation	High Inflation
	$\Delta s_{t+1}$ (1)	$\Delta s_{t+1}$ (2)
$\pi_{t+1}^e - \pi_{t+1}^{*e}$	-0.039 (0.381)	0.703** (0.097)
$R^2$	0.000	0.056
$N$	617	781

*Notes:* 1. Relative PPP is given in regression (2.15).  
2. Numbers in parentheses are Bootstrapped standard errors. \* indicates significance at 5-percent level. \*\* indicates significance at 1-percent level.

**Table A 2.4: Real UIP Regressions (1997Q3-2009Q1)**

Independent Variable	Low Inflation	High Inflation
	$\Delta q_{t+1}$ (1)	$\Delta q_{t+1}$ (2)
<i>A. Fixed Effects Regression</i>		
$r_t - r_t^*$	0.258 (0.367)	-0.026 (0.307)
$R^2$	0.001	0.000
$N$	617	781

**B. Hypothesis Testing**

Null Hypothesis	<i>t</i> -statistic	<i>p</i> -value
$b_L = 1$	2.02*	0.043
$b_H = 1$	3.35**	0.001

*Notes:* 1. Real UIP regression is given in regression (2.10):  $\Delta q_{t+1} = \mathbf{b}_{0i} + \mathbf{b}_i(r_t - r_t^*) + \mathbf{v}_{t+1}$ ,  $i = L$  for low inflation countries and  $i = H$  for high inflation countries.  
2. The hypothesis testing is performed using the two-tailed test.  
3. Numbers in parentheses are Bootstrapped standard errors to account for the generated regressors. \*\* indicates significance at 1-percent level.

**Table A 2.5: Nominal UIP Regressions-Extreme Inflation Cutoffs**

Independent Variable	Low Inflation	High Inflation	Low Inflation	High Inflation
	$\Delta s_{t+1}$ (1)	$\Delta s_{t+1}$ (2)	$\Delta s_{t+1}$ (3)	$\Delta s_{t+1}$ (4)
<i>A. Fixed Effects Regression</i>				
$i_t - i_t^*$	-2.224** (0.302)	0.383* (0.167)	-2.118** (0.249)	-0.074 (0.350)
$\pi_{t+1}^e - \pi_{t+1}^{*e}$			-0.145 (0.323)	0.750** (0.260)
$R^2$	0.035	0.028	0.038	0.072
$N$	417	450	417	450

**B. Hypothesis Testing**

Null Hypothesis	<i>t</i> -statistic	<i>p</i> -value
$\beta_L = 1$	10.69**	0.000
$\beta_H = 1$	3.69**	0.003
$\beta_L = \beta_H$	7.56**	0.000
$\beta_{1L} = \beta_{1H}$	4.76**	0.000

*Notes:* 1. Nominal UIP is given in regression (2.2):  $\Delta s_{t+1} = \beta_{0i} + \beta_i(i_t - i_t^*) + \mathbf{u}_{t+1}$ ; the augmented UIP is given in regression (2.8):  $\Delta s_{t+1} = \tilde{\beta}_i + \beta_{1i}(i_t - i_t^*) + \beta_{2i}(\pi_{t+1}^e - \pi_{t+1}^{*e}) + \tilde{\mathbf{u}}_{t+1}$ , where  $i = L$  for low inflation countries and  $i = H$  for high inflation countries.  
2. The hypothesis testing is performed using the two-tailed test.  
3. Numbers in parentheses are robust standard errors for regression (2.2) and are Bootstrapped standard errors to account for the generated regressor in regression (2.8). \* indicates significance at 5-percent level. \*\* indicates significance at 1-percent level.

**Table A 2.6: Relative PPP Regressions-Extreme Inflation Cutoffs**

Independent Variable	Low Inflation	High Inflation
	$\Delta s_{t+1}$ (1)	$\Delta s_{t+1}$ (2)
$\pi_{t+1}^e - \pi_{t+1}^{*e}$	-0.619 (0.321)	0.692** (0.111)
$R^2$	0.007	0.071
$N$	397	450

*Notes:* 1. Relative PPP is given in regression (2.5).  
2. Numbers in parentheses are Bootstrapped standard errors. \* indicates significance at 5-percent level.  
\*\* indicates significance at 1-percent level.  
3. Low Inflation is lower than the 1<sup>st</sup> quartile; High Inflation is greater than the 3<sup>rd</sup> quartile.

**Table A 2.7: Real UIP Regressions-Extreme Inflation Cutoffs**

Independent Variable	Low Inflation	High Inflation
	$\Delta q_{t+1}$ (1)	$\Delta q_{t+1}$ (2)
<i>A. Fixed Effects Regression</i>		
$r_t - r_t^*$	0.574 (0.271)	0.019 (0.286)
$R^2$	0.007	0.000
$N$	397	450

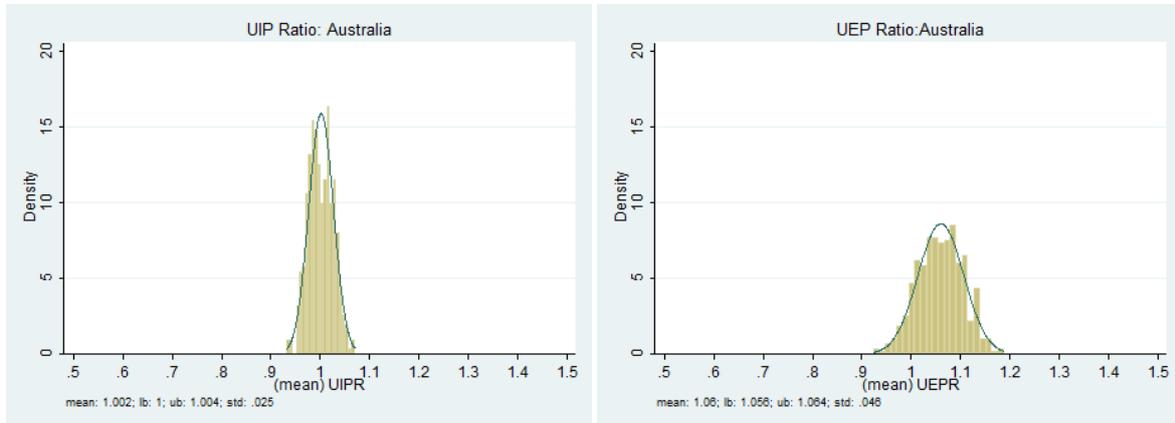
**B. Hypothesis Testing**

Null Hypothesis	$t$ -statistic	$p$ -value
$b_L = 1$	1.57	0.117
$b_H = 1$	3.43**	0.001

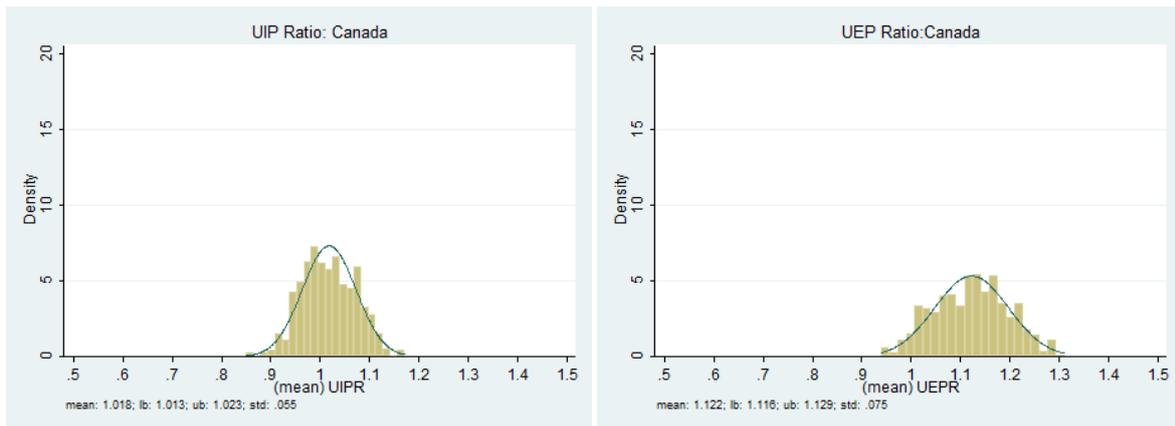
*Notes:* 1. Real UIP regression is given in regression (2.10):  $\Delta q_{t+1} = b_{0i} + b_i(r_t - r_t^*) + v_{t+1}$ ,  $i = L$  for low inflation countries and  $i = H$  for high inflation countries.  
2. The hypothesis testing is performed using the two-tailed test.  
3. Numbers in parentheses are Bootstrapped standard errors to account for the generated regressors. \*\* indicates significance at 1-percent level.  
4. Low Inflation is lower than the 1<sup>st</sup> quartile; High Inflation is greater than the 3<sup>rd</sup> quartile.

**Figure A3.1: Distribution of the UIP Ratio (left) and UEP Ratio (right)**

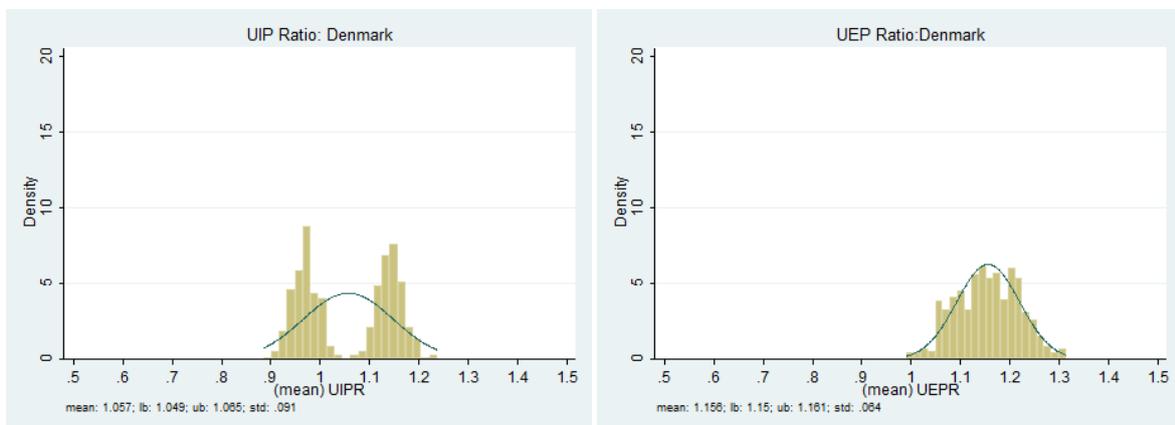
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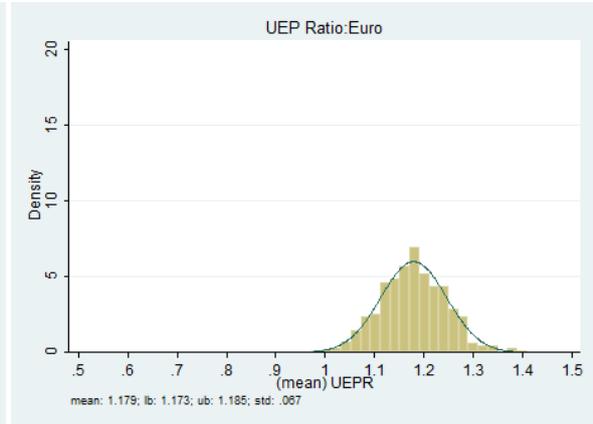
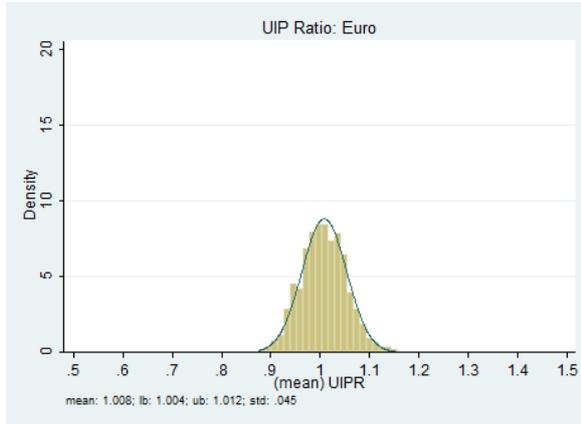
**B. Canada**



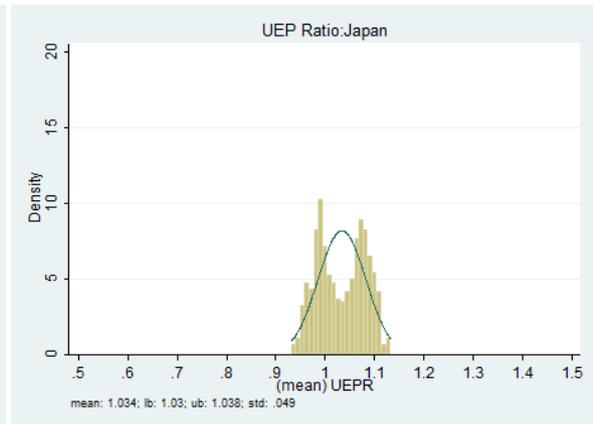
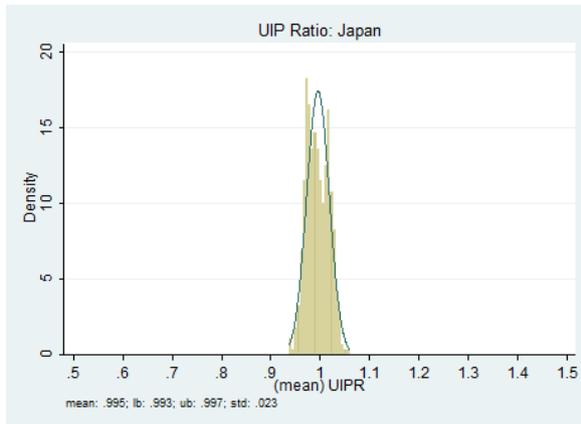
**C. Denmark**



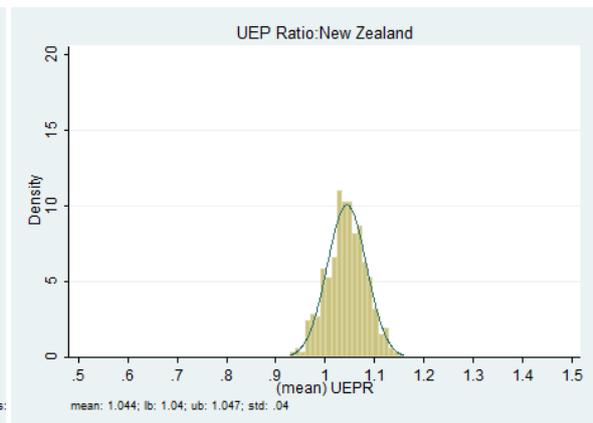
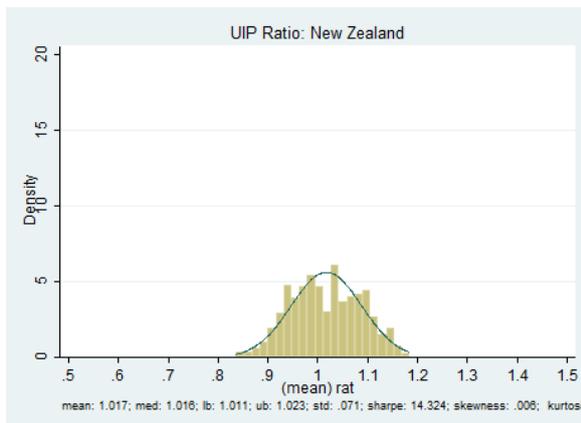
## D. Euro



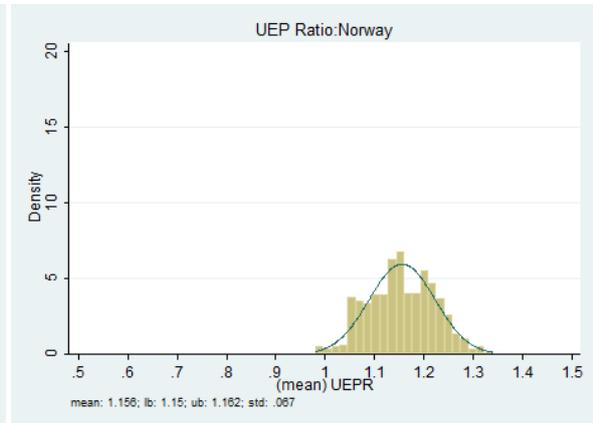
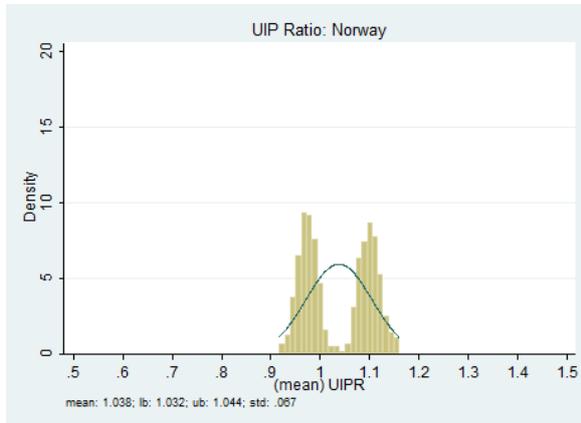
## E. Japan



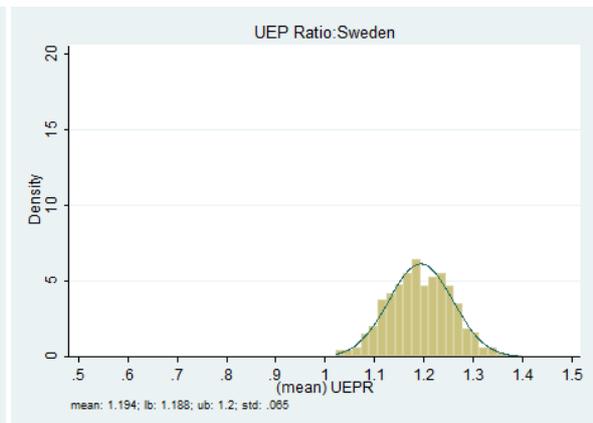
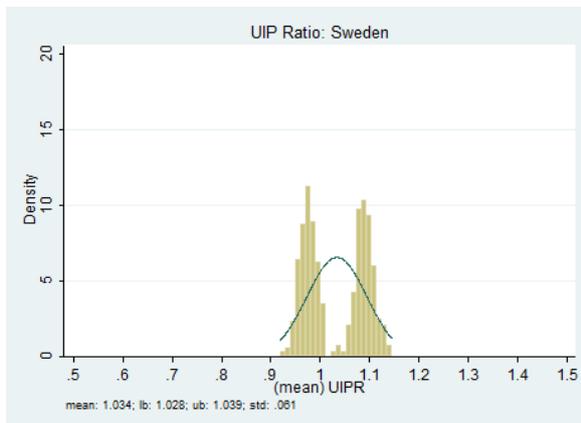
## F. New Zealand



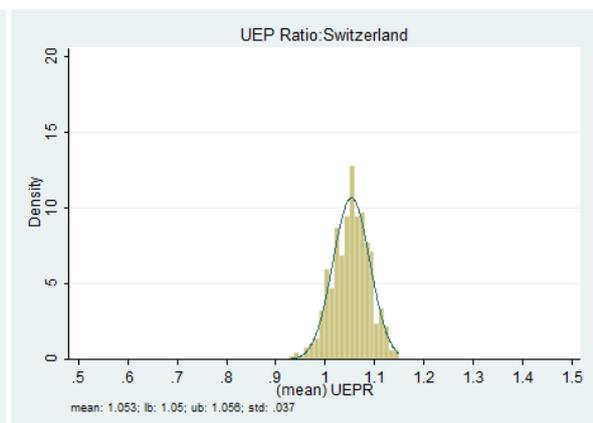
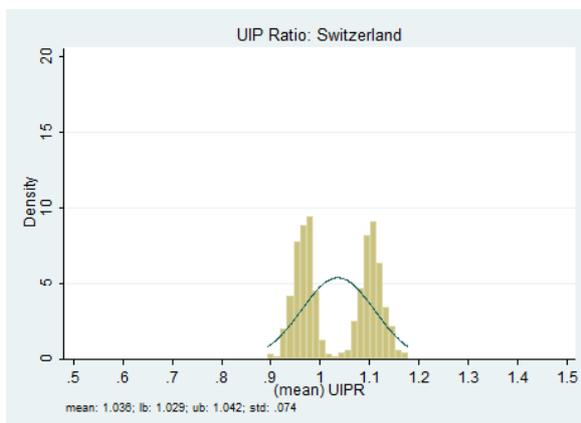
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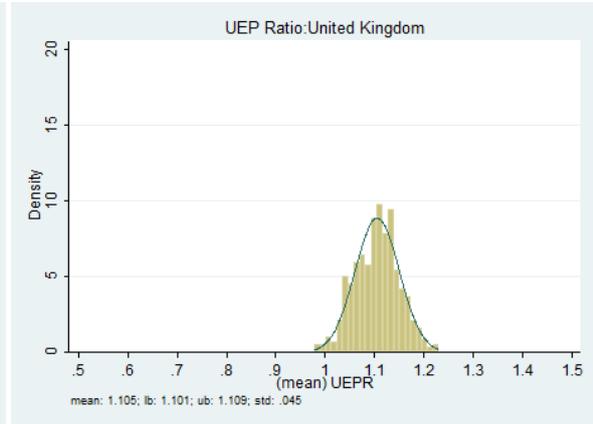
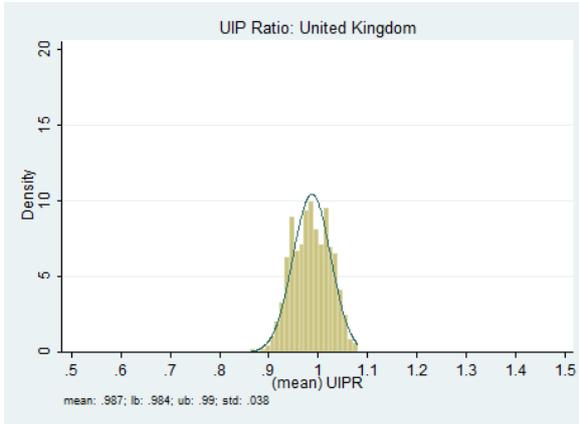
## H. Sweden



## I. Switzerland

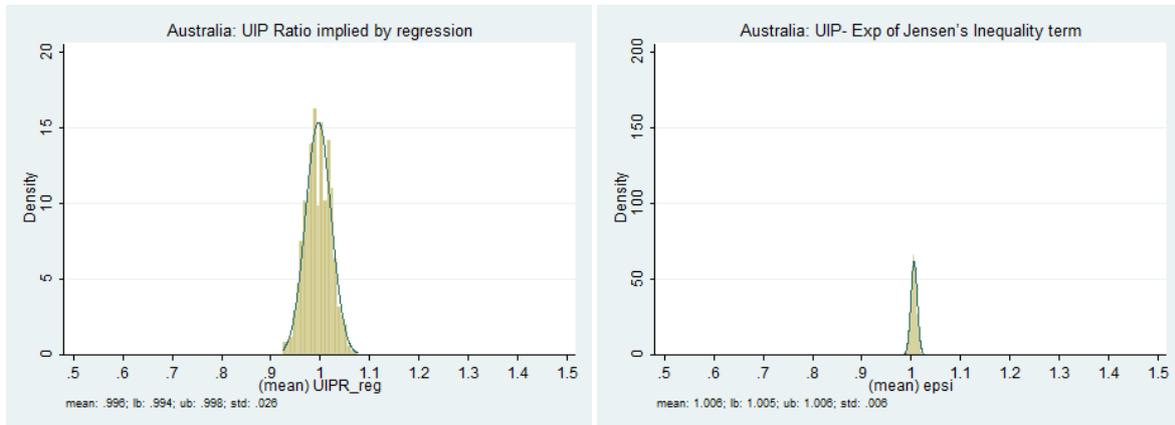


## J. United Kingdom

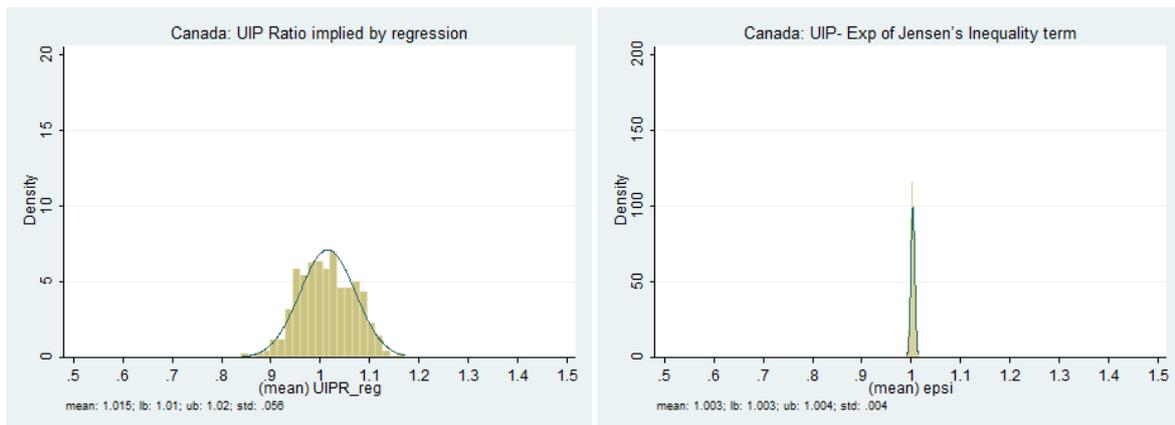


**Figure A3.2: Empirical Distribution of the UIP Ratio implied by the regressions (left) and exponential of the Jensen's Inequality Term (right)**

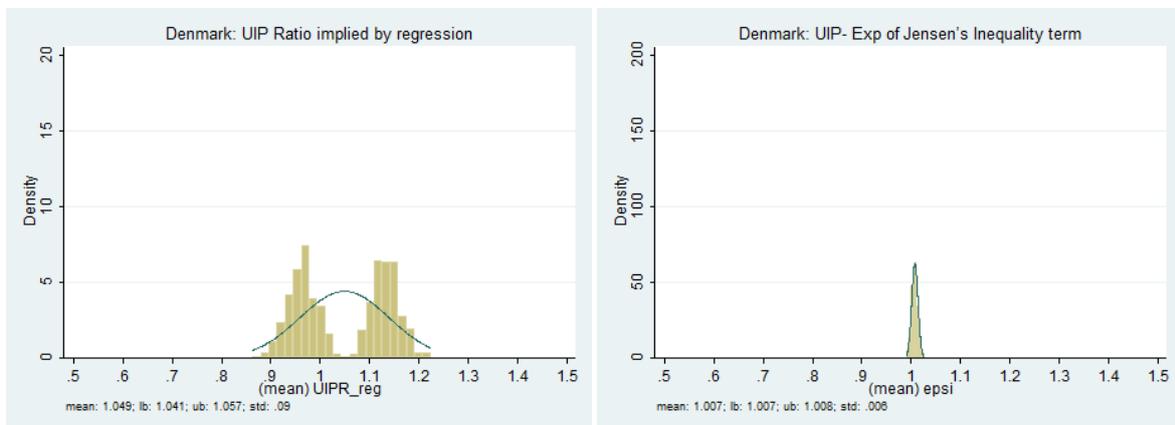
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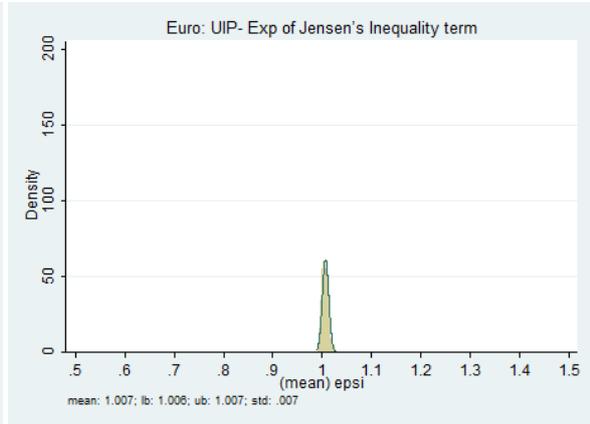
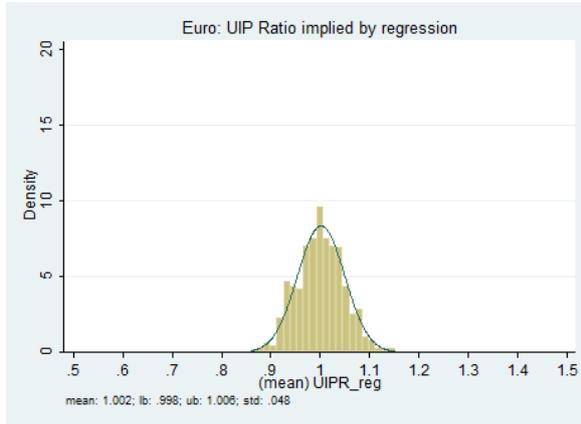
**B. Canada**



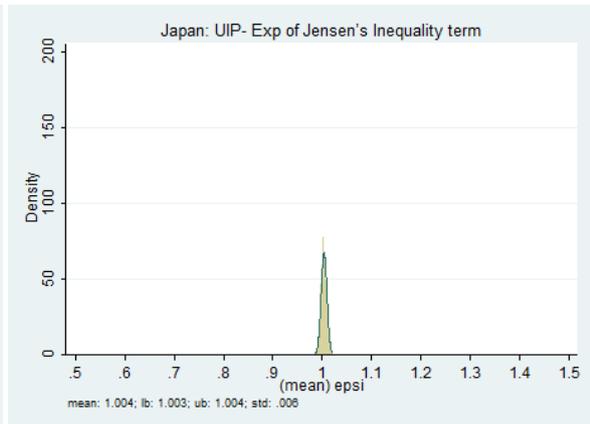
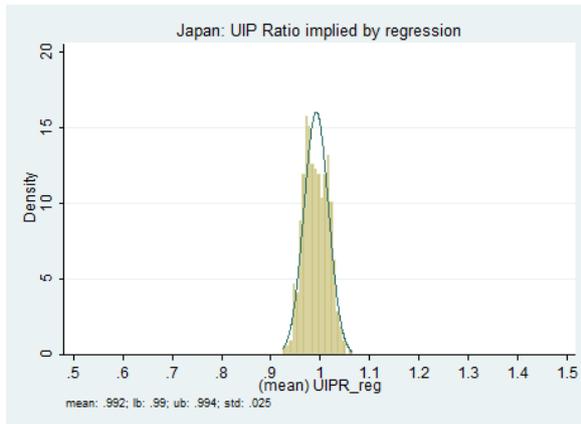
**C. Denmark**



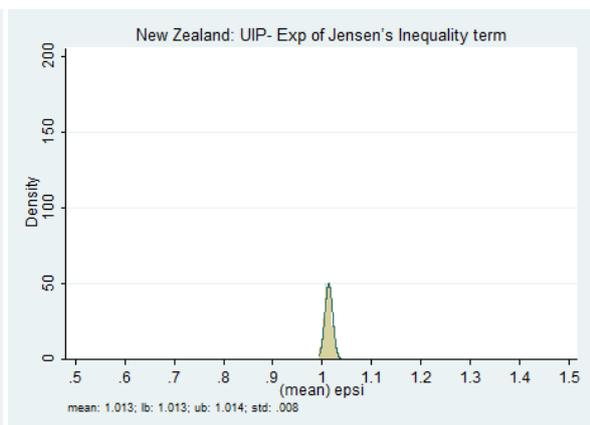
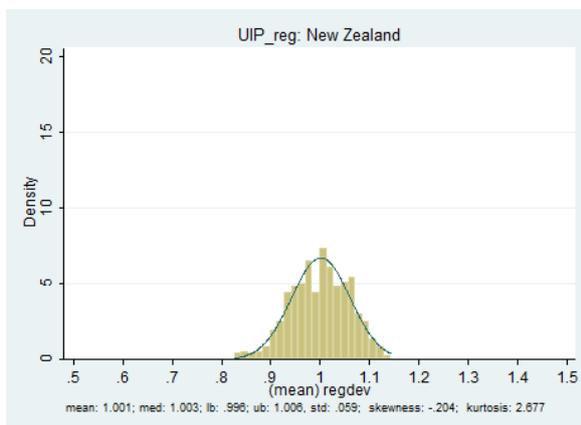
## D. Euro



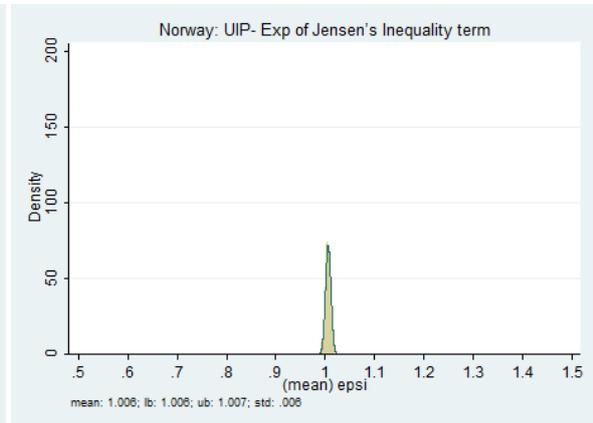
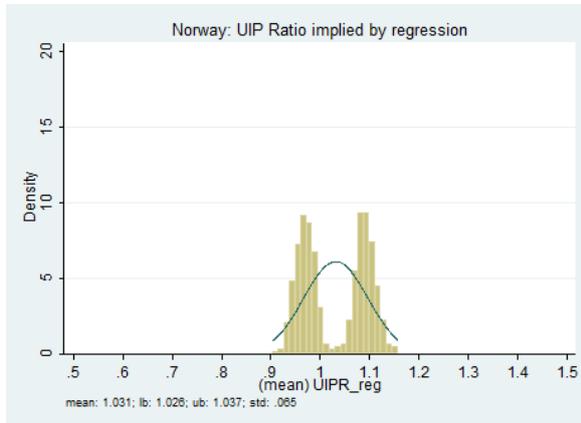
## E. Japan



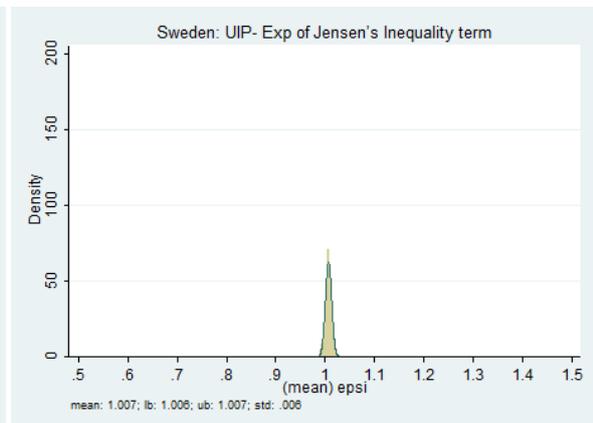
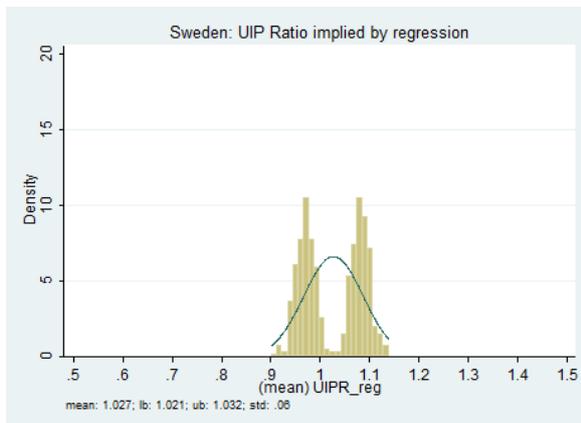
## F. New Zealand



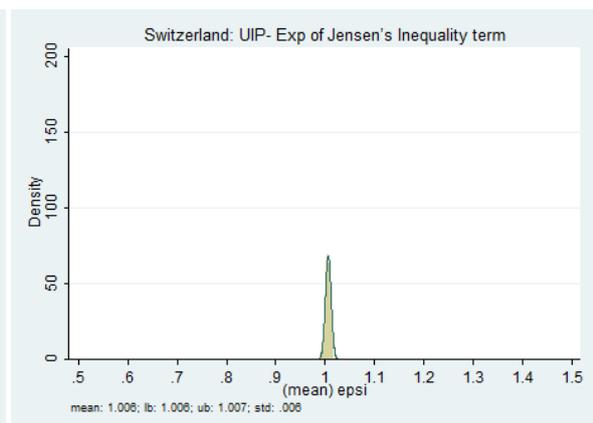
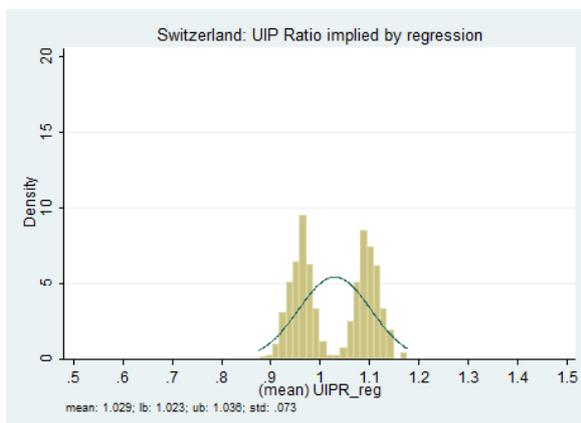
## G. Norway



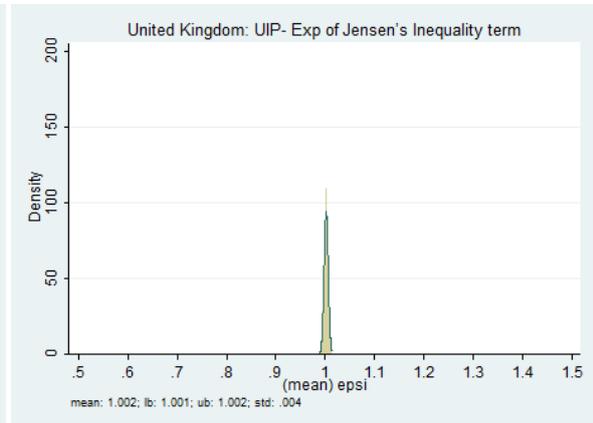
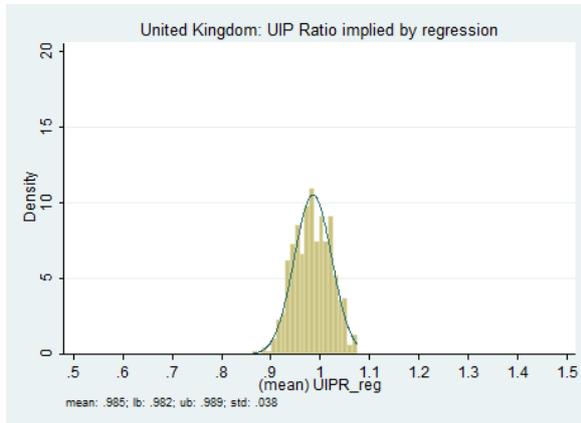
## H. Sweden



## I. Switzerland

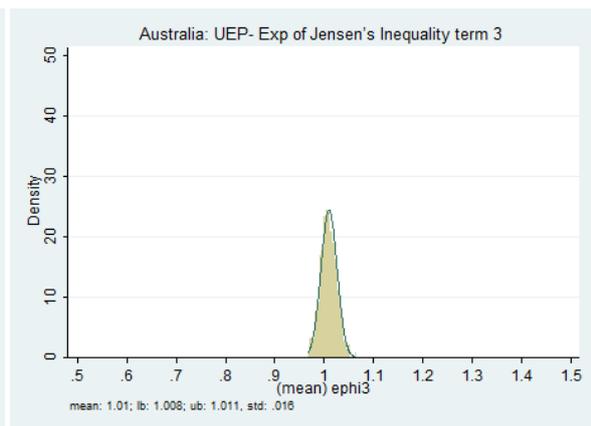
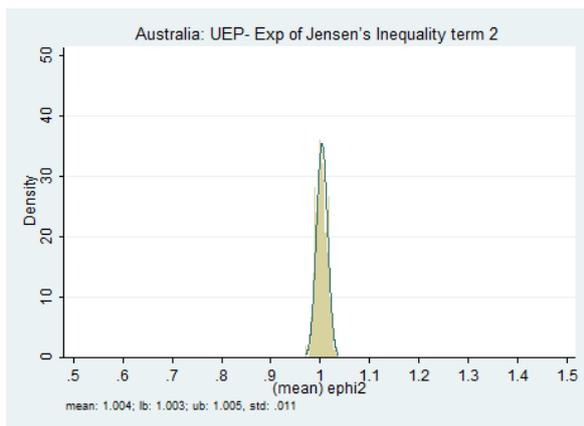
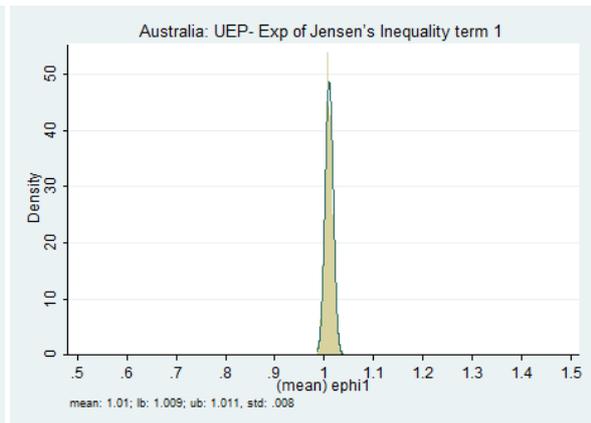
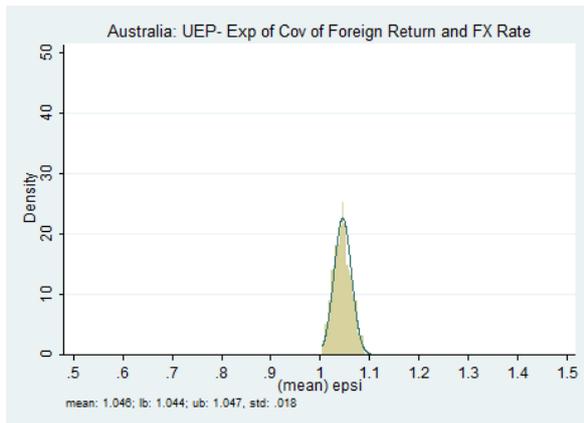
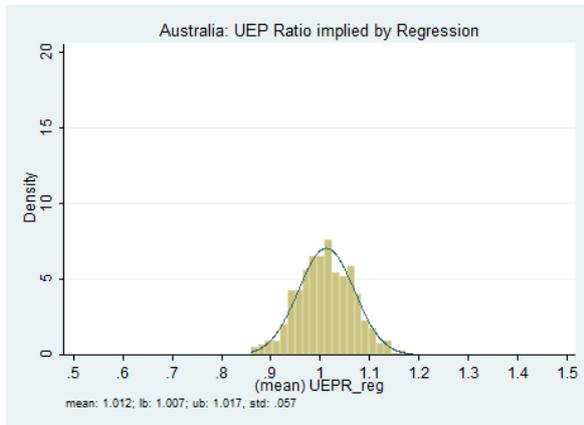


## J. United Kingdom

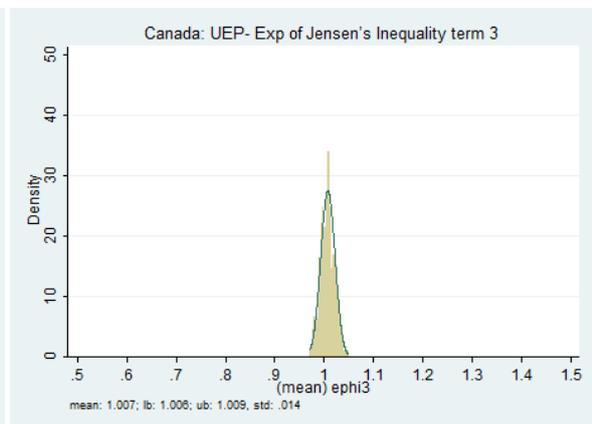
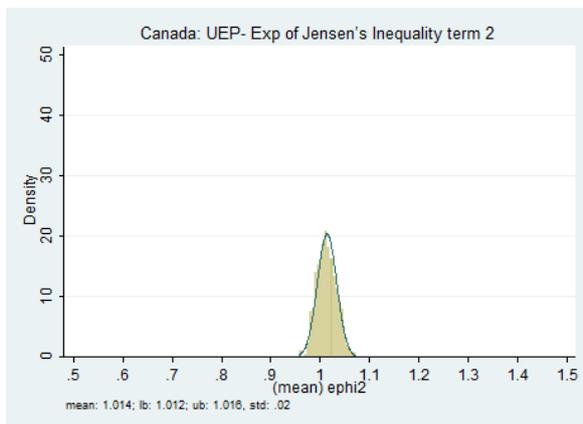
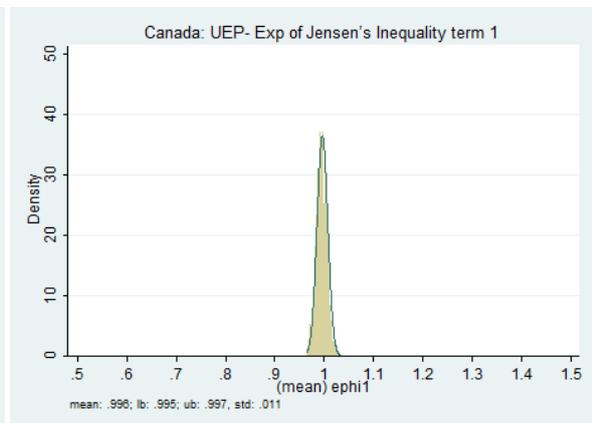
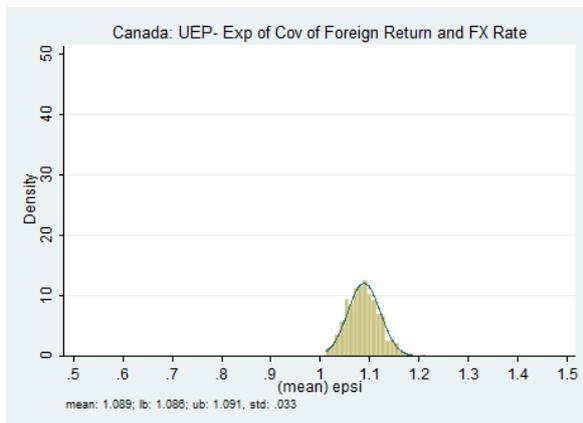
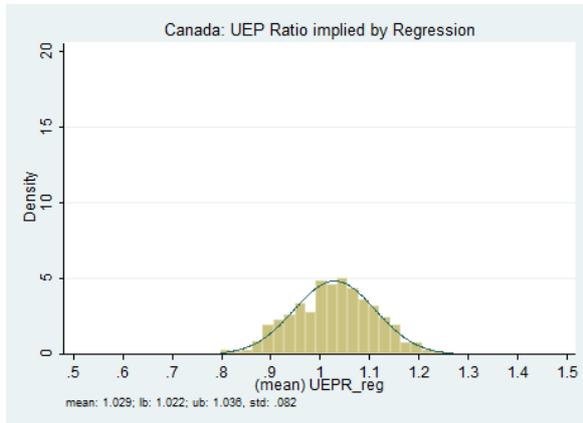


**Figure A3.3: Empirical Distributions of the UEP Ratio implied by the regression, exponential of the covariance term, and exponential of the Jensen’s Inequality terms**

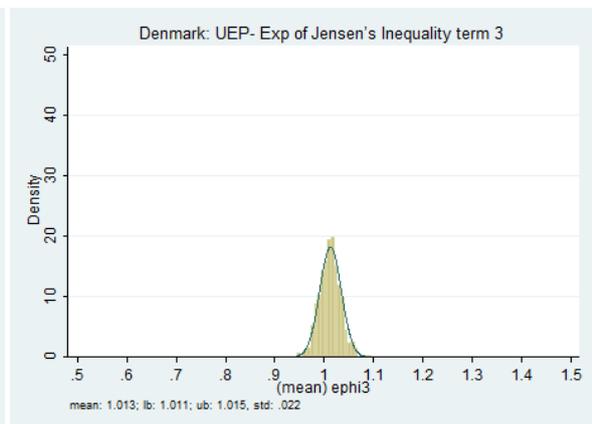
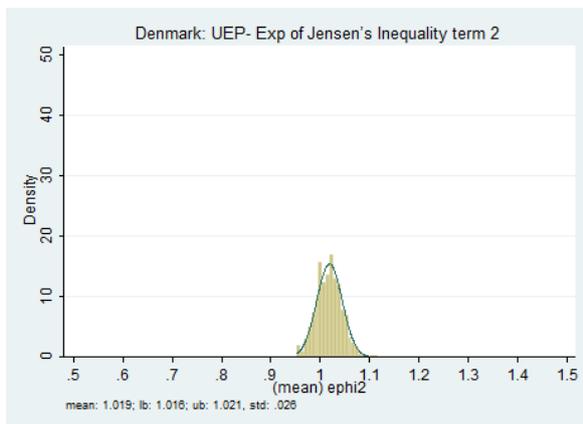
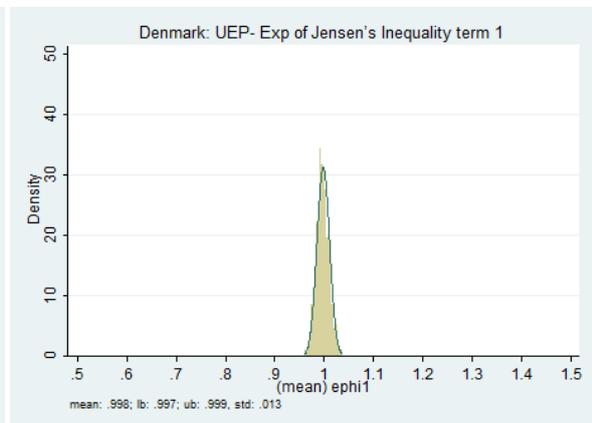
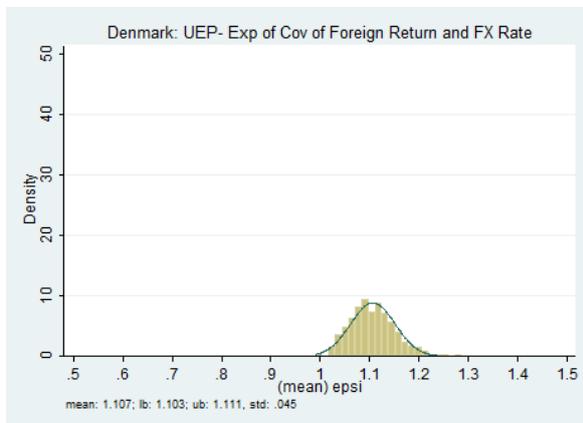
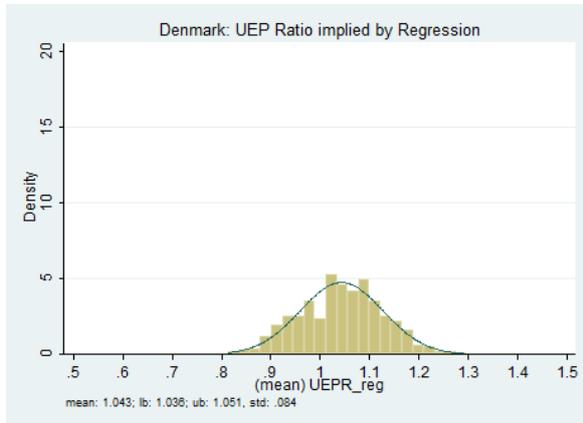
**A. Australia**



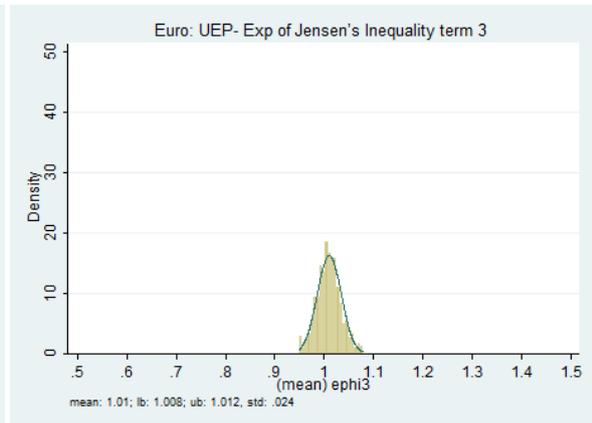
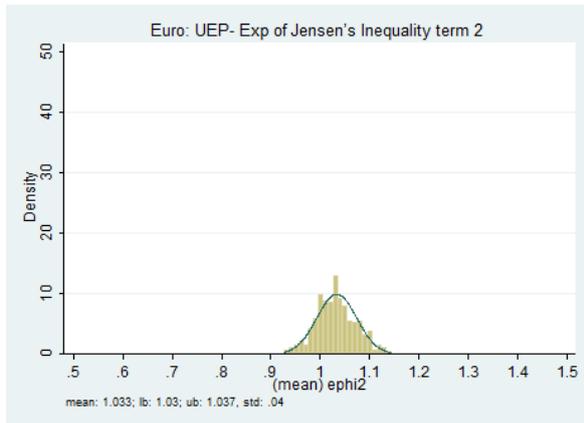
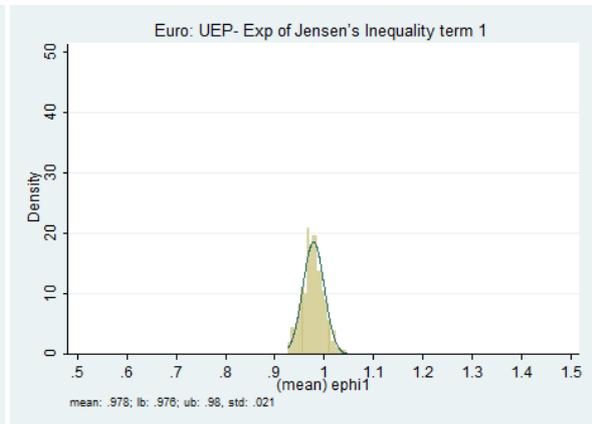
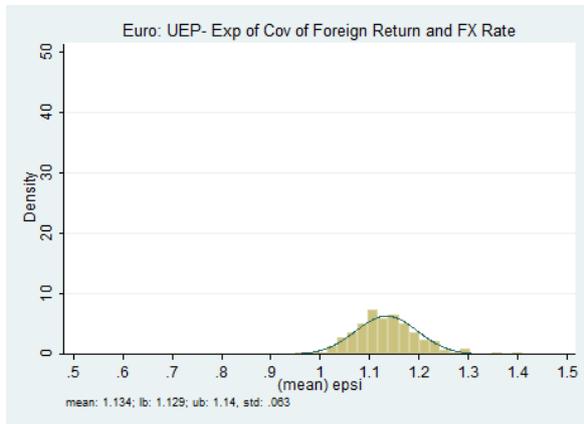
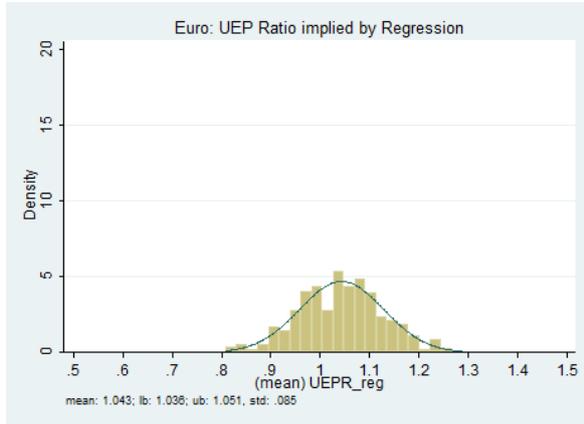
## B. Canada



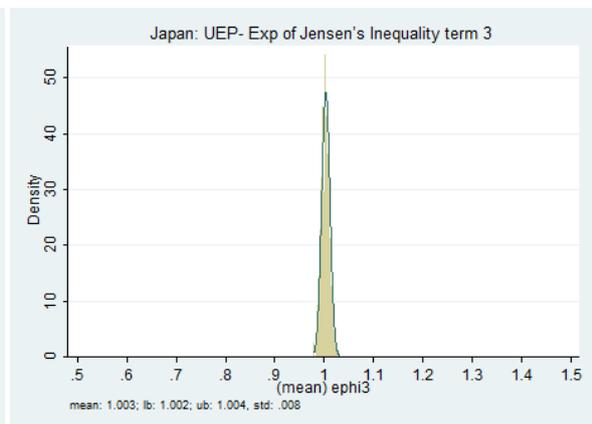
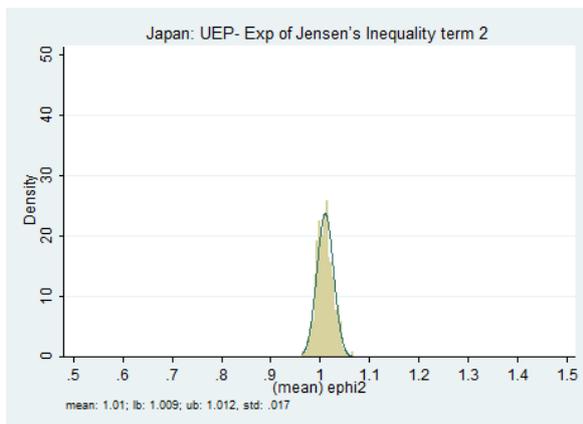
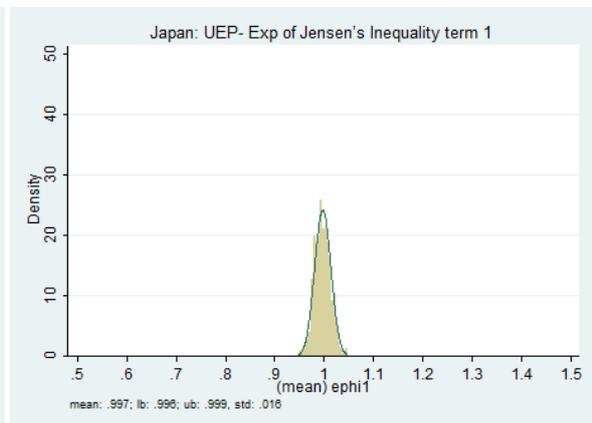
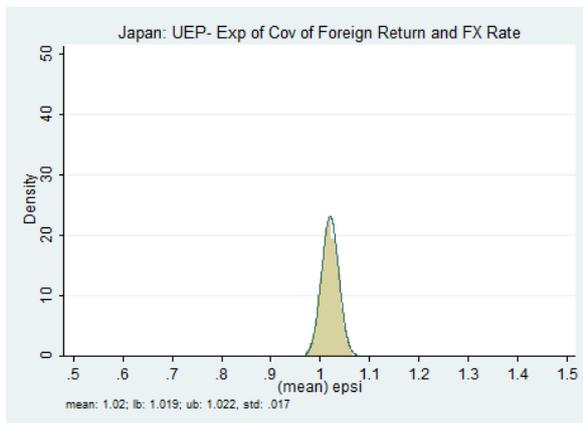
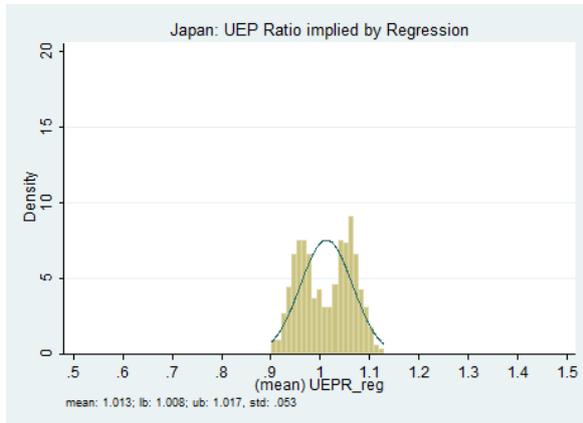
## C. Denmark



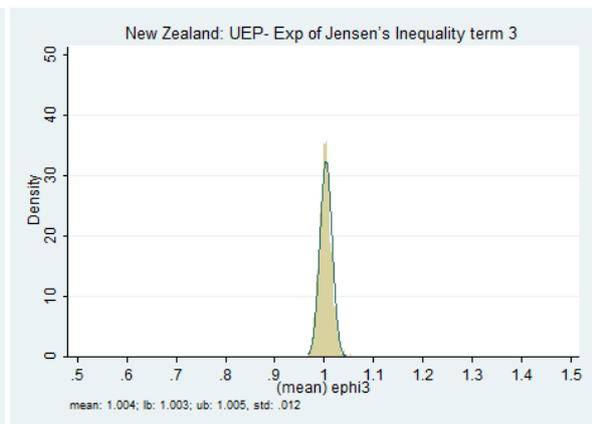
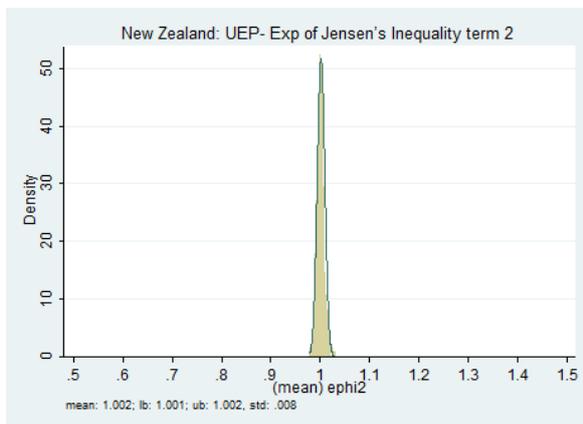
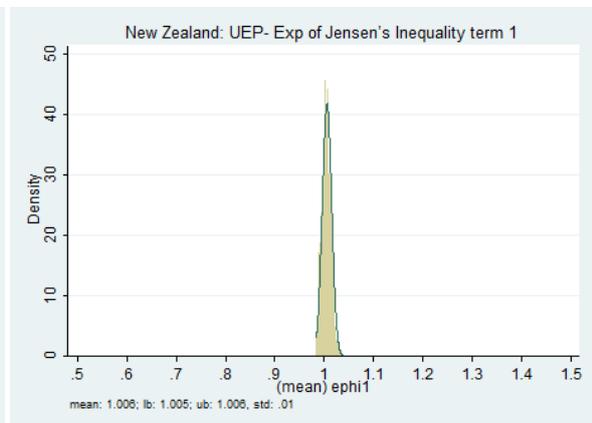
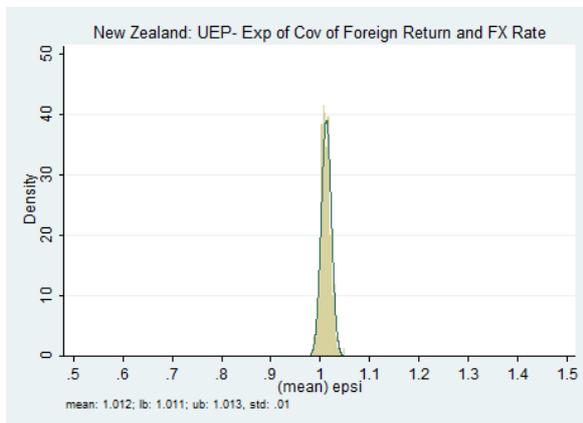
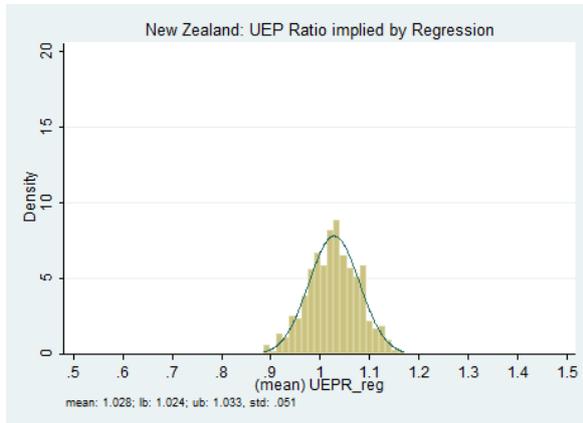
## D. Euro



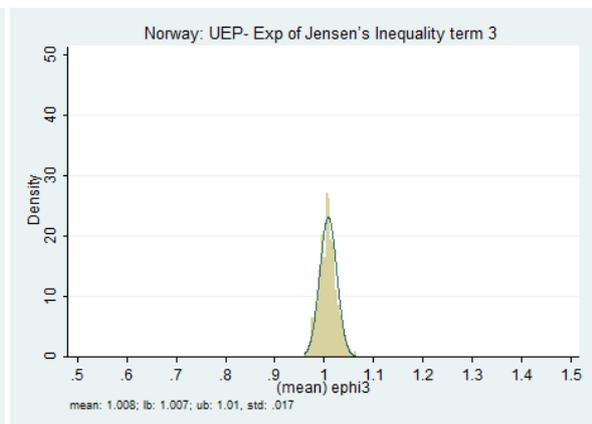
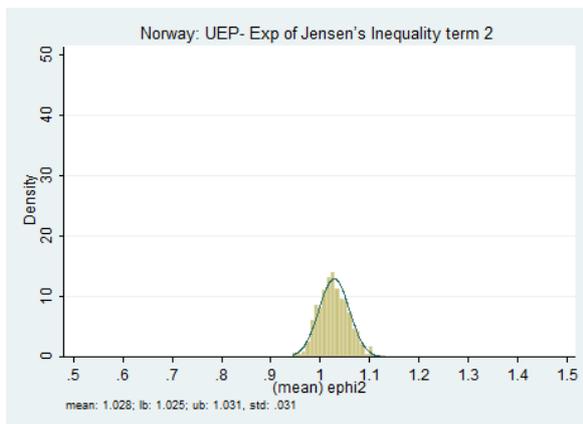
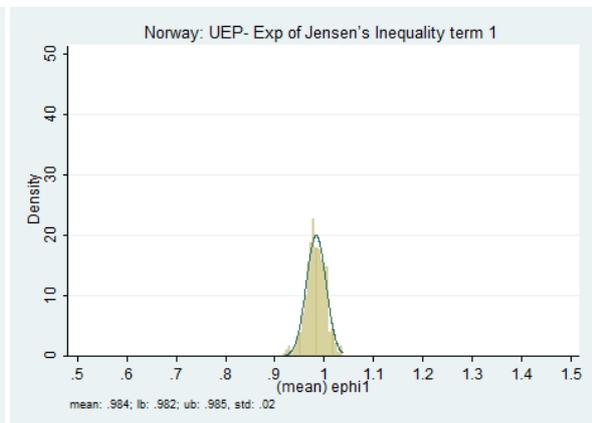
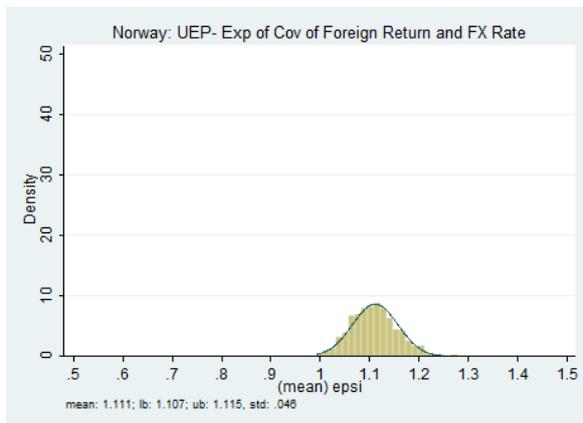
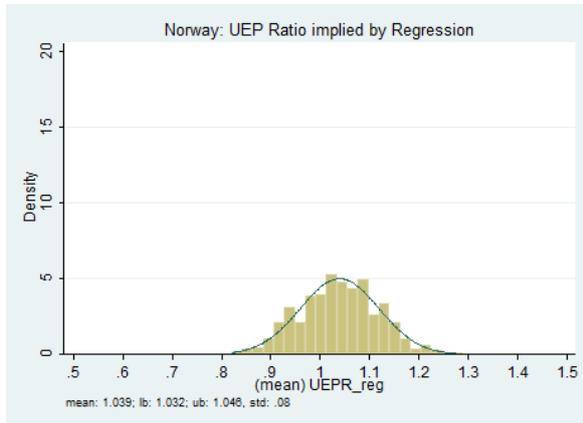
## E. Japan



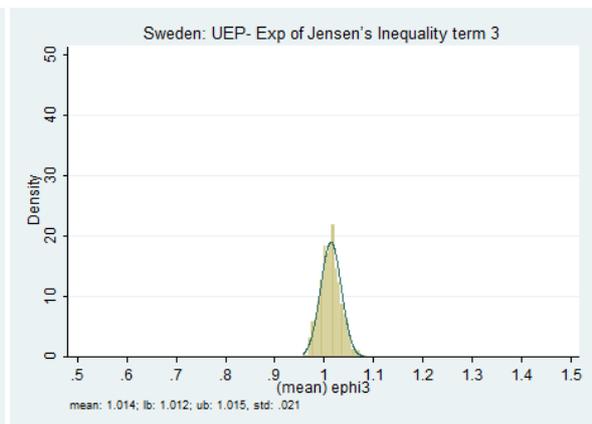
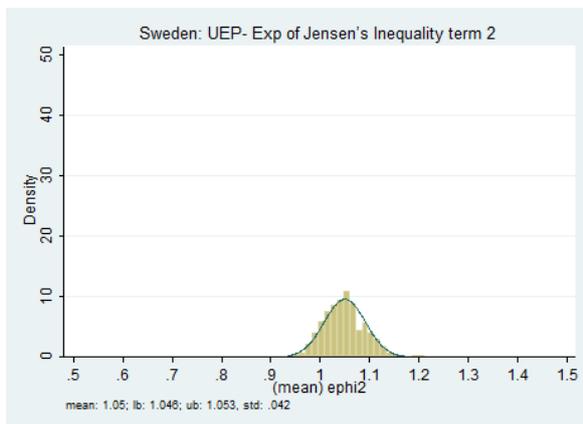
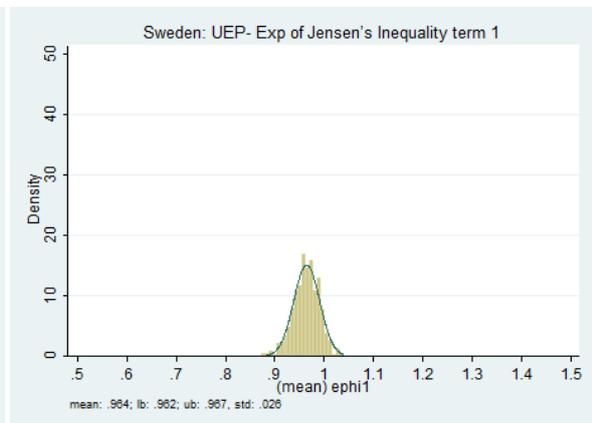
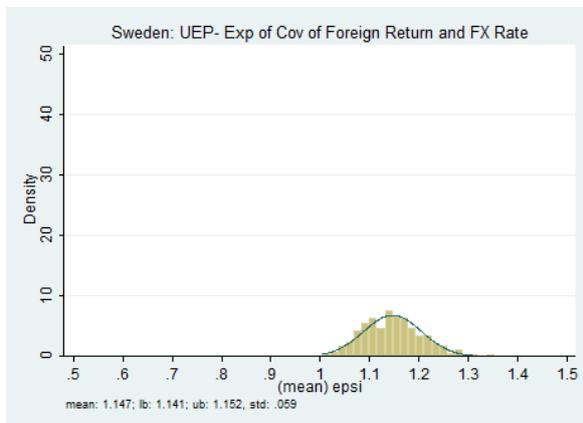
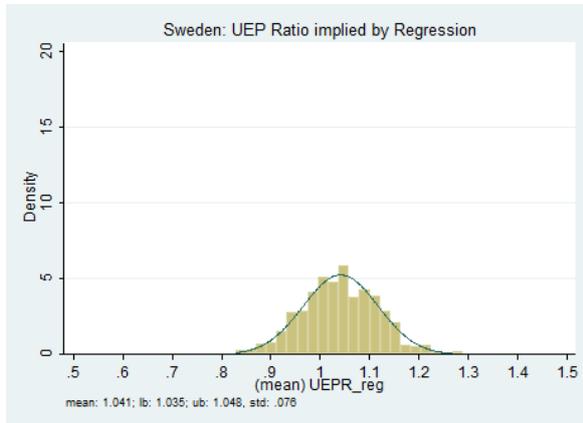
## F. New Zealand



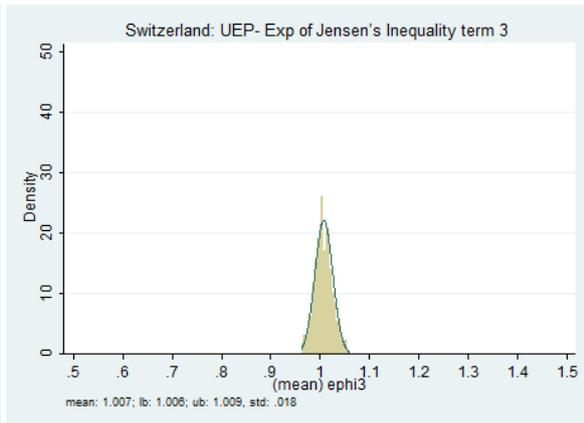
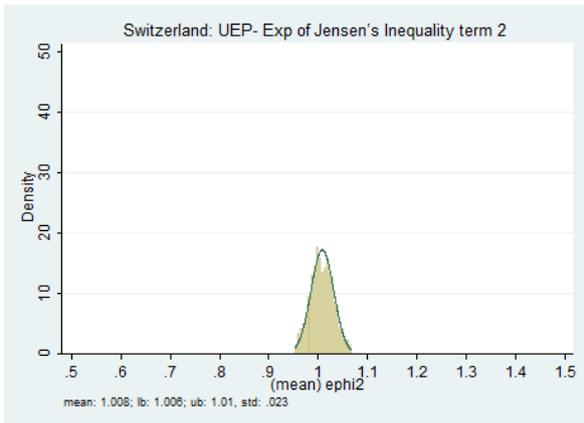
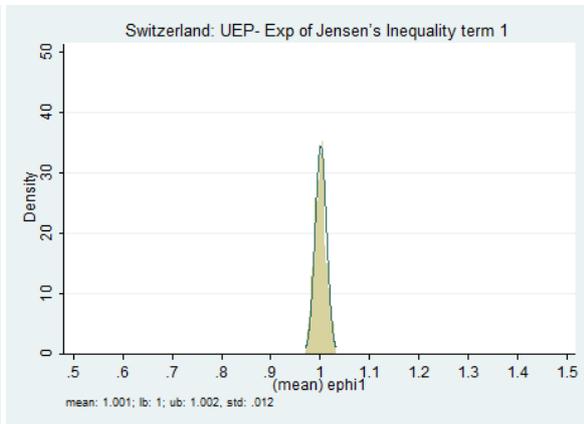
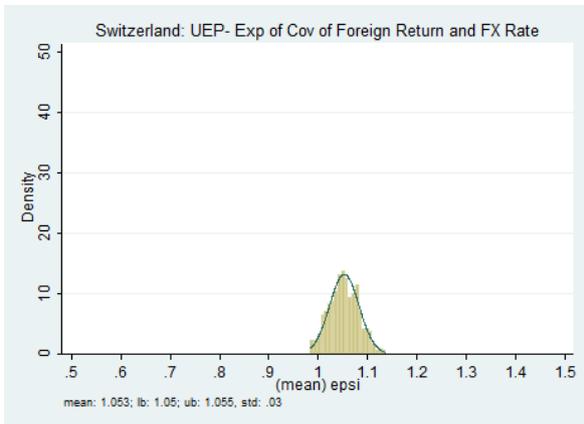
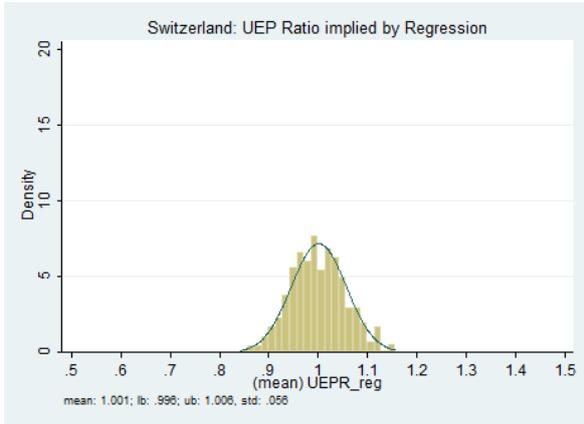
## G. Norway



## H. Sweden



# I. Switzerland



## J. United Kingdom

